



CMS
CMS Center
and Research Program
Lothar A. T. Bauerdick

DOE Annual Program
Review



Overview

- **Brief update on LHC**
- **Status of CMS Detector**
 - update on sub-component status and installation
 - particular emphasis on Fermilab deliverables
- **Getting Ready for Physics**
 - CMS Commissioning, Software, Computing, Physics Preparations
- **CMS Center and U.S. CMS Research Program**
 - LHC Physics Center, Remote Operations Center
- **Summary and Conclusion**



LHC Installation Overview

Cryo-magnets:

All cryo-magnets are in the tunnel

Interconnections:

6 arcs are now closed

(3-4, 4-5, 5-6, 6-7, 7-8 & 8-1)

Interconnections work will finish soon.

Inner triplets:

All low- β magnets have been repaired,
interconnection work proceeds

Cool down, warm-up:

teething problems solved, leaks repaired,
X-ray of plug-in modules shows problems

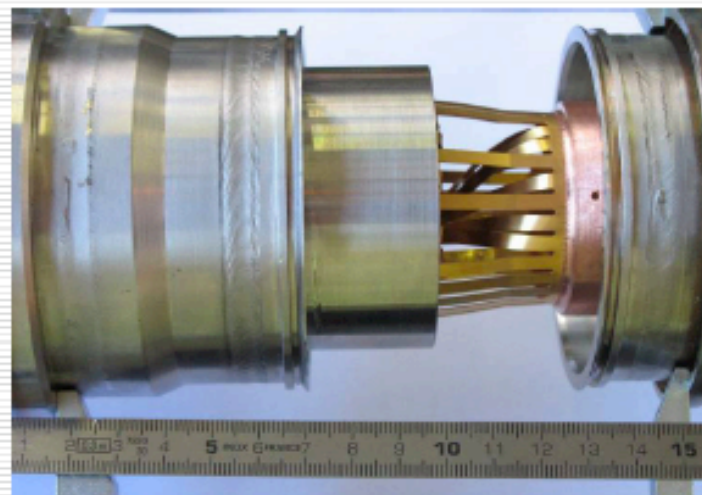
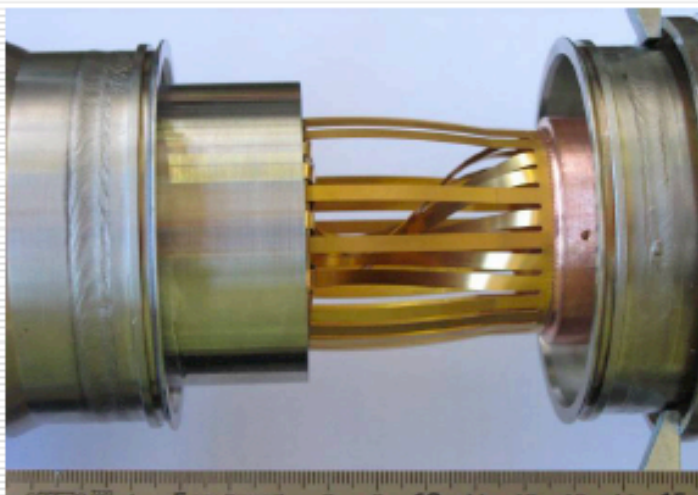
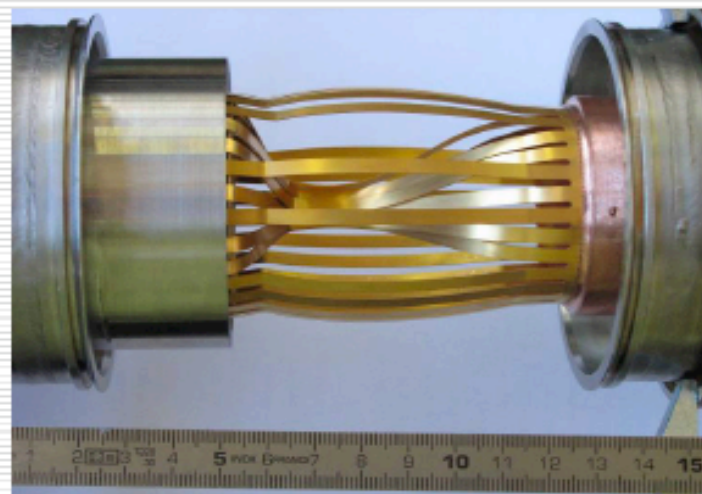
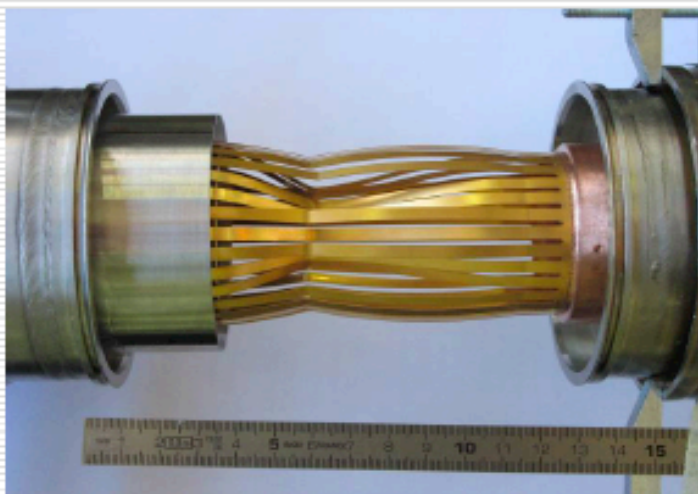


Last Dipole being lowered
Apr07

Damaged Plug-In Modules



- The total number of damaged plug-in modules on the beam lines in the arc (sector 7-8) is five out of 450: together with the five in the dispersion suppressor region (where damage was expected)



General LHC Schedule

(L.Evans, as shown by T.Virdee last week)

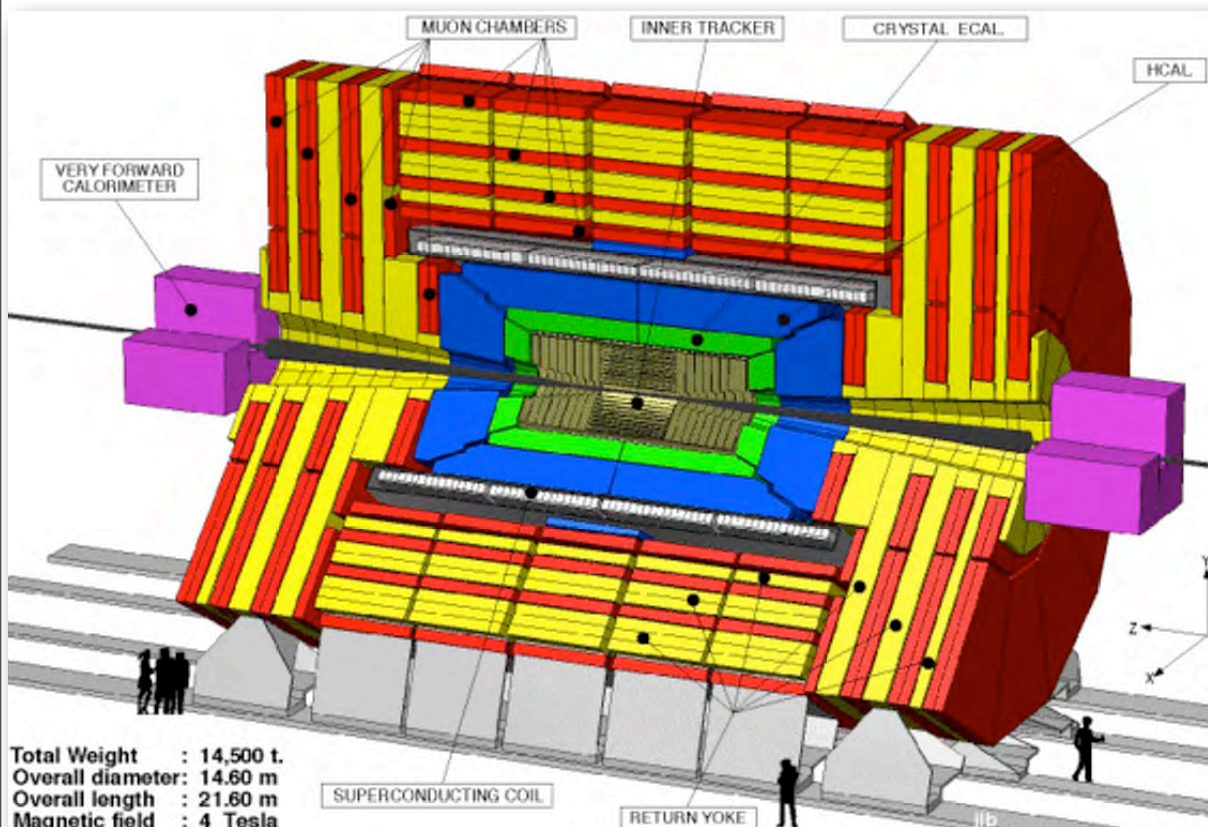


- Engineering run originally foreseen at end 2007 now precluded by delays in installation and equipment commissioning.
- 450 GeV operation now part of normal setting up procedure for beam commissioning to high-energy
- General schedule has been revised, accounting for inner triplet repairs and their impact on sector commissioning
 - All technical systems commissioned to 7 TeV operation, and machine closed April 2008
 - Beam commissioning starts May 2008
 - First collisions at 14 TeV c.m. July 2008
 - Luminosity evolution will be dominated by our confidence in the machine protection system and by the ability of the detectors to absorb the rates.
- No provision in success-oriented schedule for major mishaps, e.g. additional warm-up/cooldown of sector

Installing CMS Underground

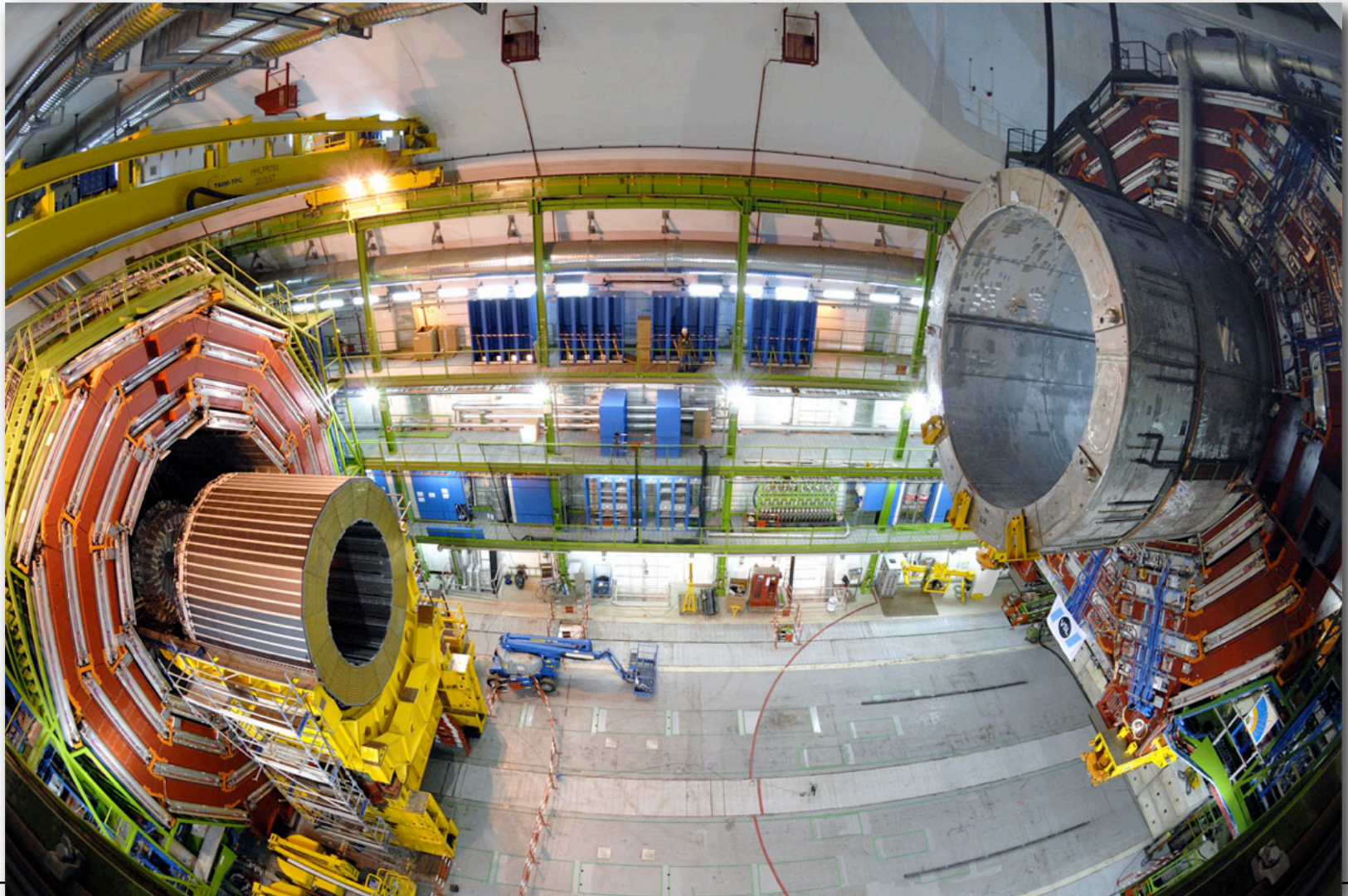


- CMS has to install the entire detector and electronics in about 1 year
 - due to late delivery of CMS Underground Cavern UX5 CMS assembled in large pieces
 - above ground testing / staging — very short installation and in-situ debugging period



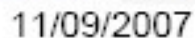
| Section | CMS Designation | Weight in tonnes |
|---------|-----------------|------------------|
| 1 | HF+ | 250 |
| 2 | YE+3 | 410 |
| 3 | YE+2 | 880 |
| 4 | YE+1 | 1310 |
| 5 | YB+2 | 1250 |
| 6 | YB+1 | 1250 |
| 7 | HB+ | 700 |
| 8 | YB0 | 1920 |
| 9 | HB- | 700 |
| 10 | YB-1 | 1250 |
| 11 | YB-2 | 1250 |
| 12 | YE-1 | 1310 |
| 13 | YE-2 | 880 |
| 14 | YE-3 | 410 |
| 15 | HF- | 250 |

Feb 28, 2007: YB0 lowered



September 26, 2007

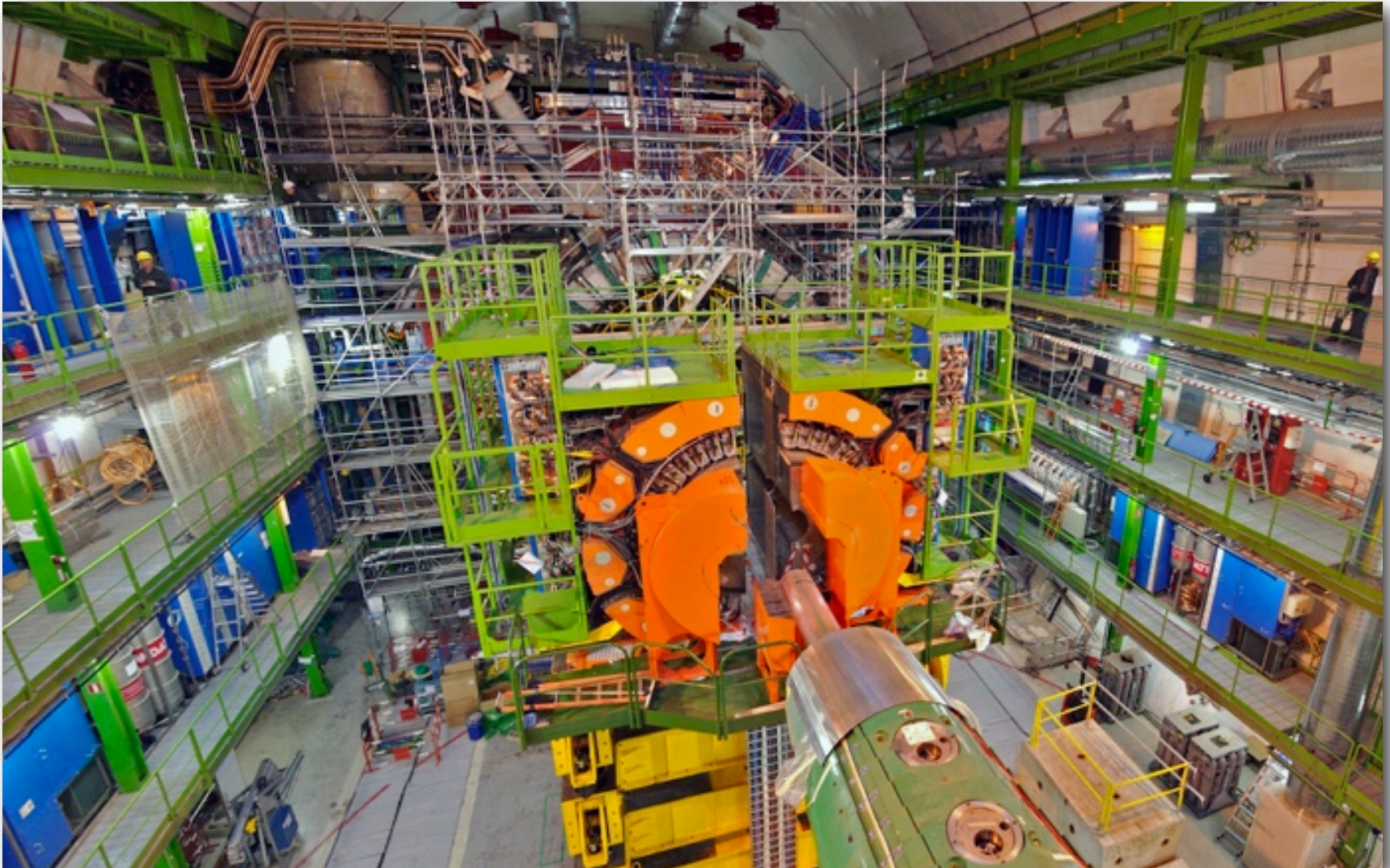
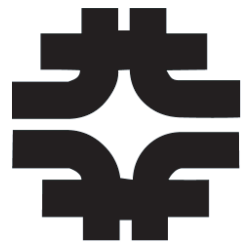
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Martin.Gastal@cern.ch

36

Current Situation in UX5 Cavern



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Fermilab heavily involved in CMS installation and commissioning

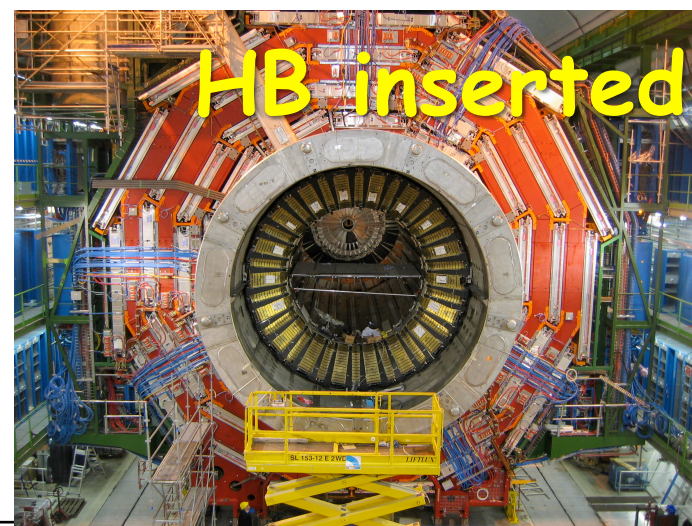
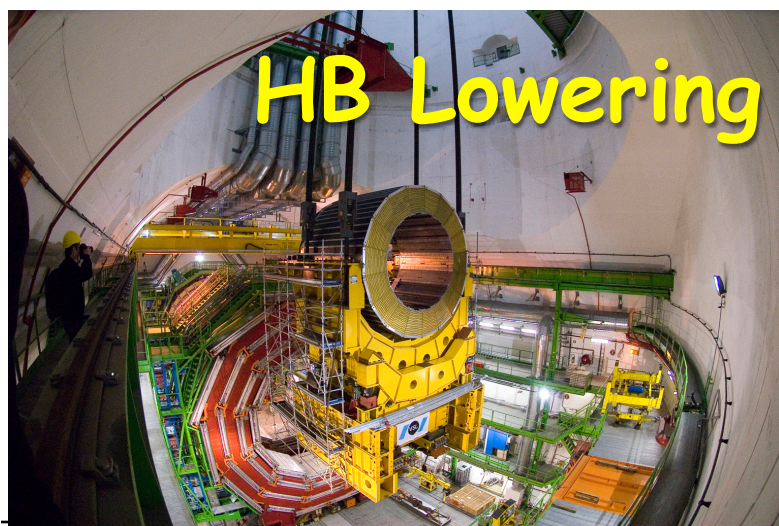
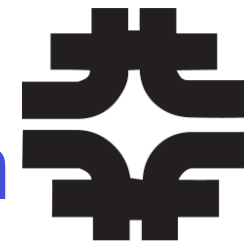


- **Highlights of areas with particular Fermilab involvement**
 - **CMS Installation in cavern is fully underway**
 - **Whole positive side and solenoid and central yoke block are in the Collision Hall, services/cables being installed**
 - **HB and EB are installed in the Solenoid, HF put in position**
 - **The remaining muon detectors are upstairs, complete, and ready for lowering**
 - **Silicon Strip Tracker Commissioning and Integration at Tracker Integration Facility TIF is complete and detector is being packed up for move**
 - **Substantial part of electronics is now in the Underground Service Cavern**
 - **FPIX is $\sim 3/4$ done and $1/2$ is delivered to CERN**
 - **Global runs with DAQ and Trigger at P5 underway**
 - **Test beam for calorimeter have started**
 - **Preparations are underway for resumption of MTCC**



Status of CMS Sub-Components

HCAL installation in CMS Cavern



September 26, 2007

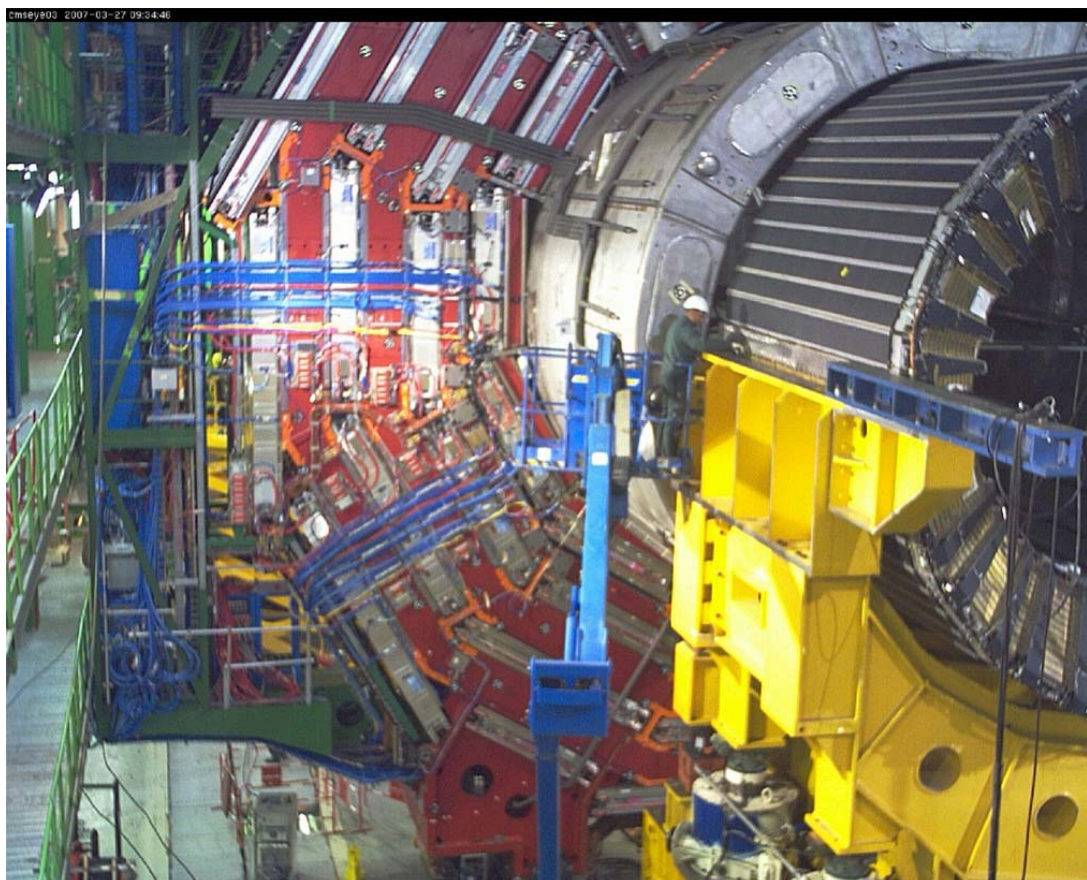
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12

HCAL Is Complete!



- Detector ready and installed — Barrel installed into YB0
- Good progress with installation in Underground Service Cavern
- Global Readout tests with HF being successful
- Problem with Noise in HPDs being worked on





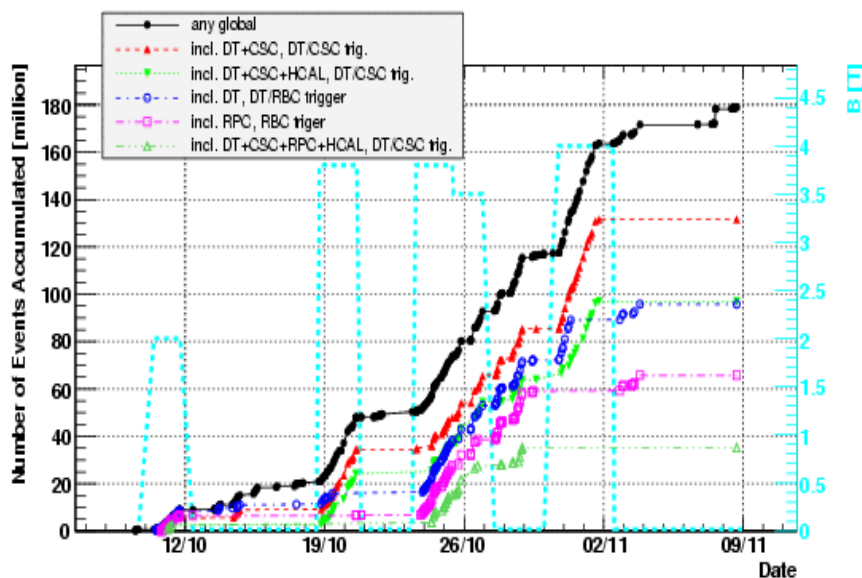
- **Collaborating Institutions:** Boston University, Fairfield, Florida Institute of Technology, Florida International, Florida State, FNAL, U of Illinois, Chicago, U of Iowa, Iowa State, Kansas, Maryland, Minnesota, Mississippi, Northwestern, Notre Dame, Princeton, Purdue, Rochester, Rockefeller, Texas A&M, Texas Tech
- - **Fermilab: 8 Physicists, 1 GS, 1 RA, 3 Students**
- **Status:**
 - Installation of cabling and services to the detectors in UXC underground cavern (HF, HB, HE+, HO (+2,+1,0));
 - Continued commissioning of the HF+ detector using LED signals;
 - Installation of remaining HCAL trigger electronics crates, validation of cabling, and continued integration with the CMS calorimeter trigger electronics;
 - Preparations for data taking (monitoring, data integrity checks, database visualization, tools, calibration, simulations);
 - Preparations for HPD noise study and lifetime tests;
 - Preparations for beam tests of the combined HE/EE/ES sub-detectors;
 - Preparations for SiPM beam tests as a study of replacement photo-detection equipment for HO HPDs.
 - Work on offline DB/online DB/DCS DB is proceeding.
 - Detector Control System (DCS) , Detector Safety Systems (DSS) electronics is being installed and tested.
- **Issues:**
 - Because cooling water is not available to HE+, readout boxes cannot be powered for longer than 2-3 hours without risk of prematurely aging the electronics from overheating. The June Global run preparations included short detector commissioning runs with HE+ readout. However, further integration will be difficult until services to the detector are completed.
 - - the HPD noise issue that surfaced in the MTCC.
 - Adequate RBX LV modules are in hand for commissioning. However, there has been a recall on these boards and they will need to be returned to the factory for a repair to be made. The goal is to keep enough modules in hand to continue commissioning.
 - Software development is a big issue. This includes DBs, online DQM, and offline.

Endcap Muons Installation

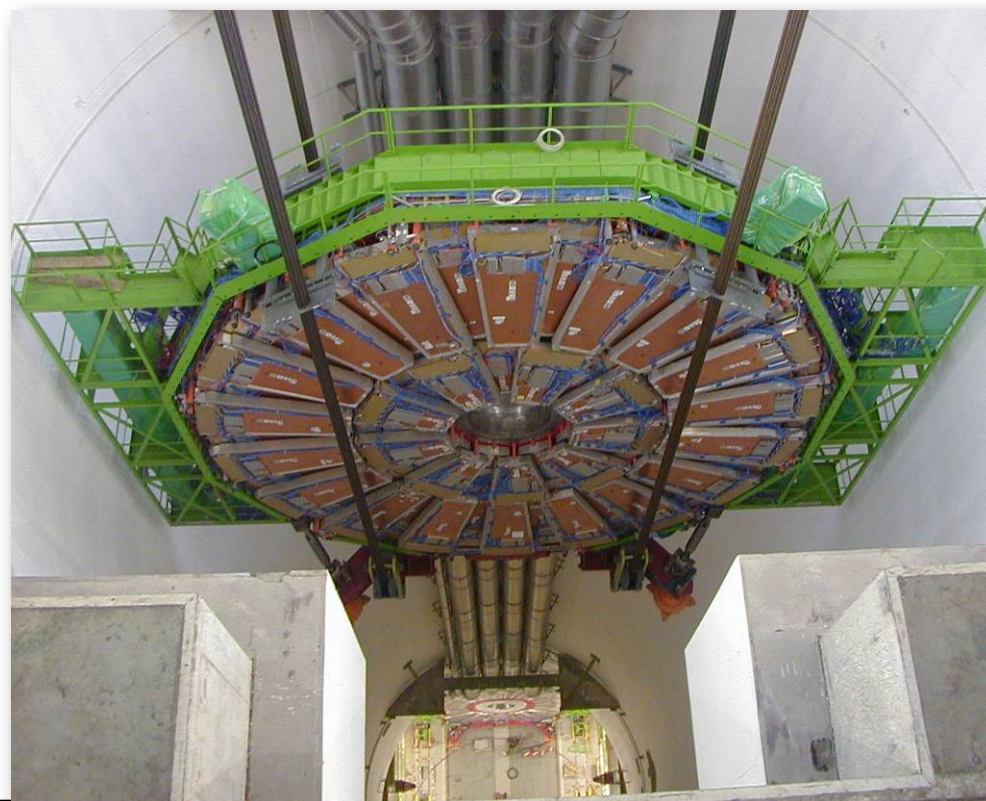


- Stable Operation above ground — 24/7 shift crew operation
- Large amount of cosmic events recorded for various B-field settings
- Muon Endcap actively participated both in the trigger and data readout

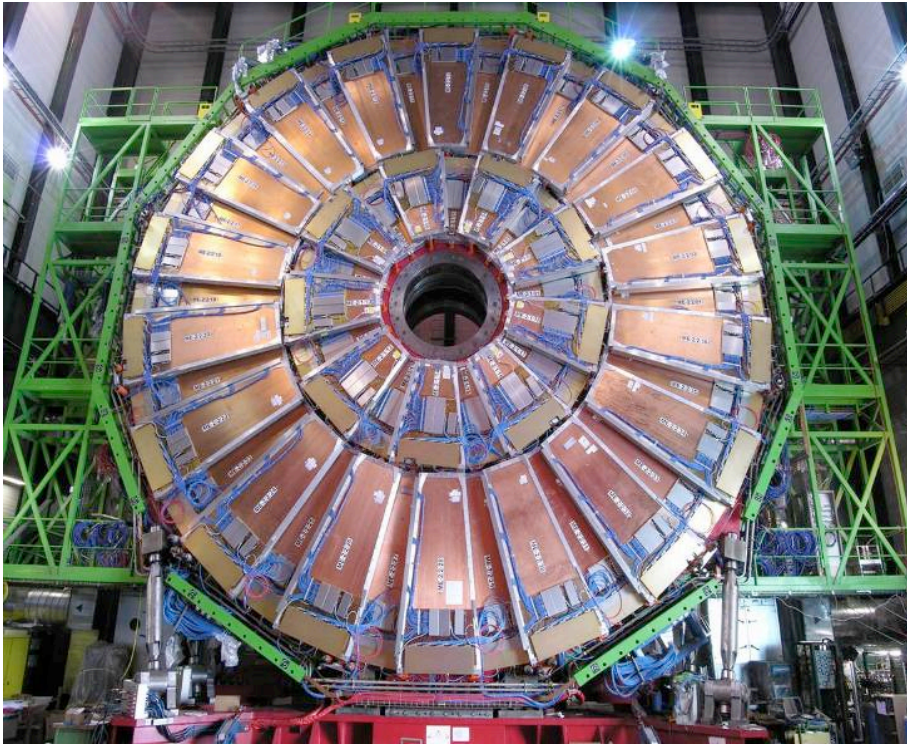
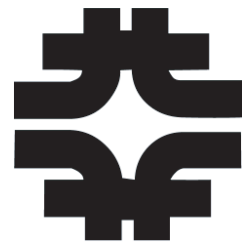
Taking Cosmic Data
above ground: MTCC



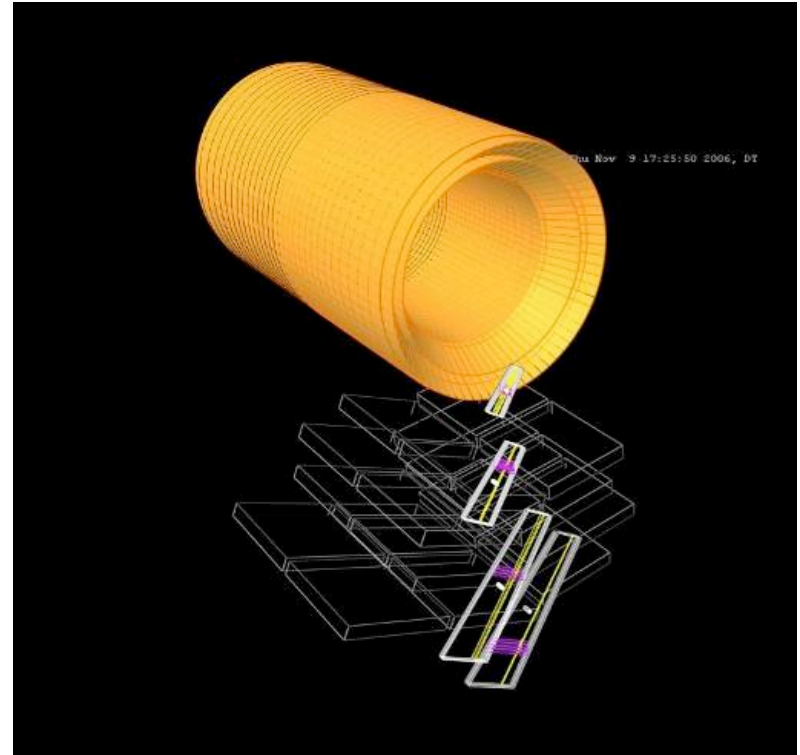
YE+2 Lowering (Dec 12)



Muon Installation and Commissioning



One of Eight
CSC Stations



CSC+DT triggered event
(using GMT+GT)

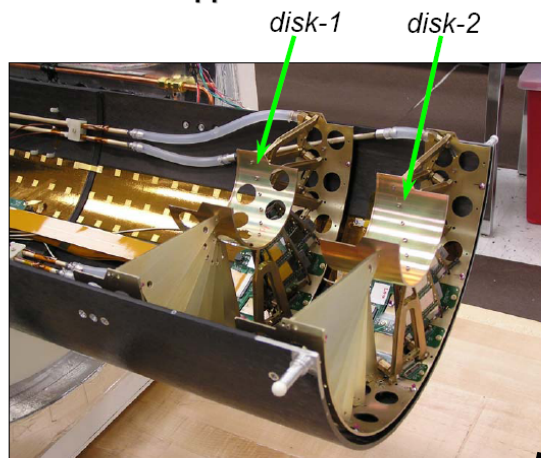


- **Collaborating Institutions:** UC Davis, UCLA, UC Riverside, Carnegie Mellon, FNAL, U of Florida, Florida Institute of Technology, Northeastern, Northwestern, Ohio State, Purdue, Rice, Texas A&M, Wisconsin
- ➔ **– Fermilab: 5 Physicists (2 based at CERN)**
- **Status:**
 - Last of 468 CSC chambers installed, Mar. 8, 2007
 - All on-chamber electronics for both endcaps installed and commissioned (60 crates total)
 - Installation of electronics – computers, fiber optics, FED crates (50%) services - in USC55 is well along
 - Large fraction of HV and LV installed and commissioned
 - To maintain flexibility in trigger as Luminosity rises, electronics is highly programmable, requiring lots of engineering support
 - Online software work to scale to full system, make more easy for non-experts, improved diagnostic and testing capability
 - Ran a slice test throughout the year, taking data, providing triggers to other subsystems
 - Participated in MTCC – doing the same with up to 36 chambers (~10% of system)
- **Issues**
 - ➔ **– Commiss. of +Z side, in pit since end of 2006, given missing services, competing activ.**
 - Commiss. of -Z side, in light of late arrival in pit (last major system to be lowered)
 - Engineering support, especially for FPGAs and physicist support as operating conditions change throughout the life of experiment
 - Alignment system issue has now been addressed. A plan is approved and being implemented

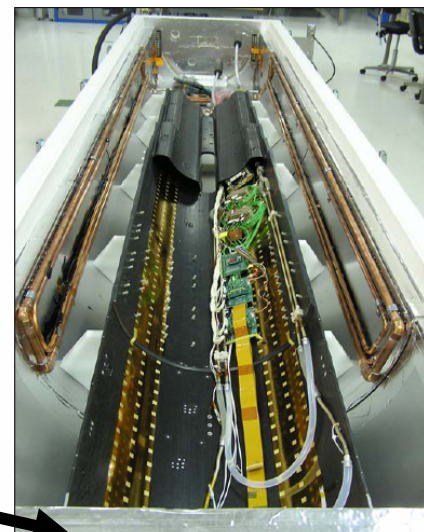
Forward Pixel Detector



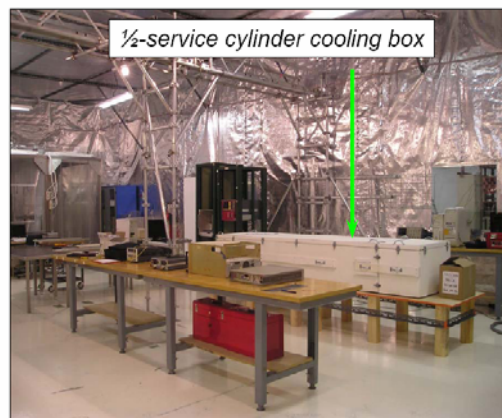
The pilot run detector was fully assembled and tested at Fermilab, then shipped to CERN



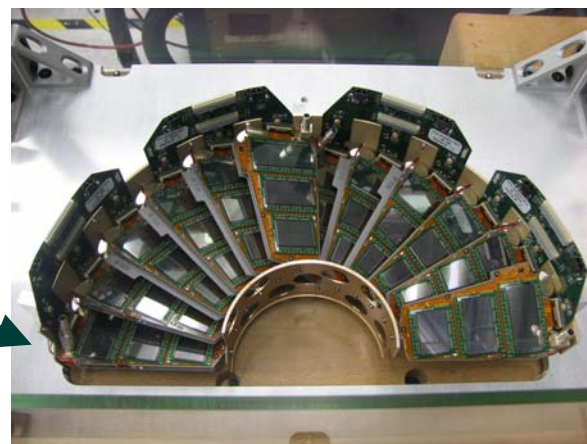
Environmental Chamber and half-cylinder at CERN (PIC)



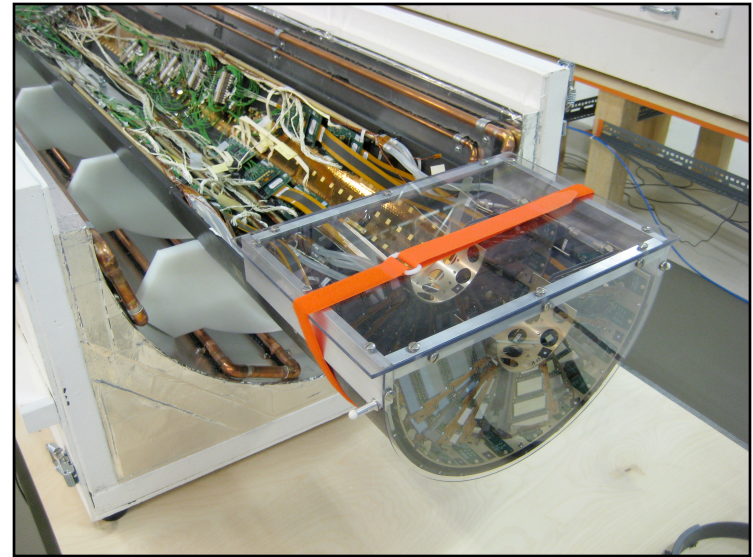
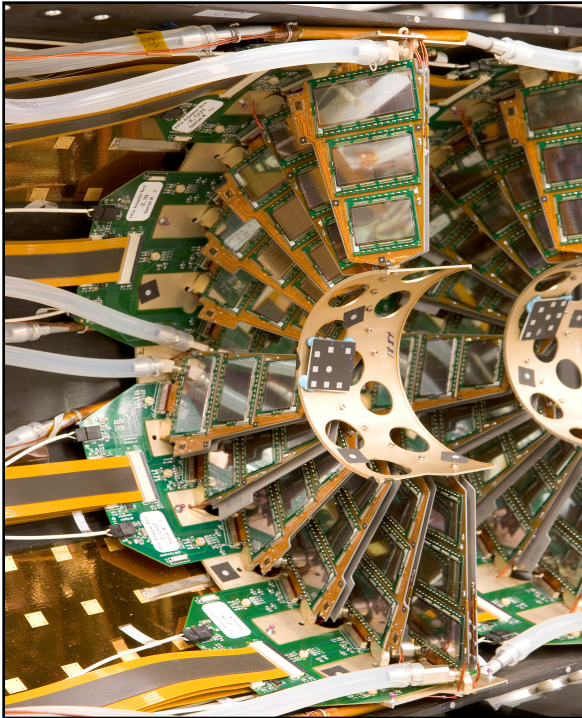
- Petal Integration Facility (PIC), next to the Tracker Integration Facility (TIF)
- Location where we will (re)commission FPIX



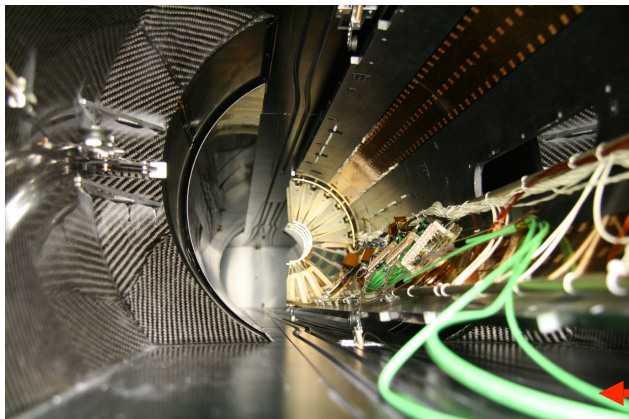
First of 8 production Half-rings. 2nd now also complete. 3rd being assembled



Pixel detector at CERN



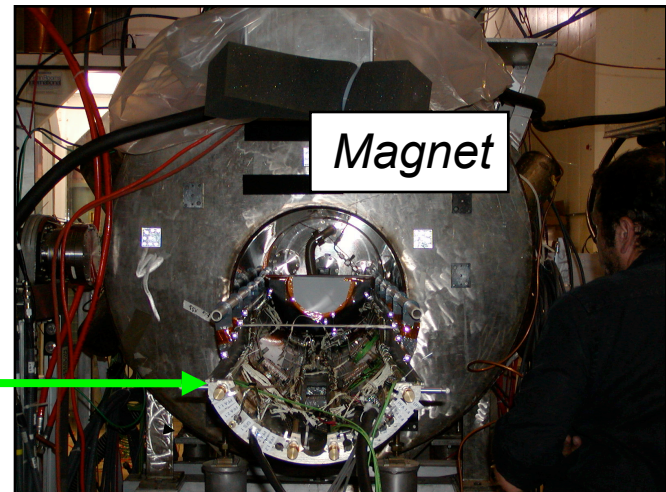
HC-Z1 and HC-Z2 are currently at CERN.



FPIX in Tracker

Test in 4 T field
At Muon Test
Facility (FNAL)

Our detector



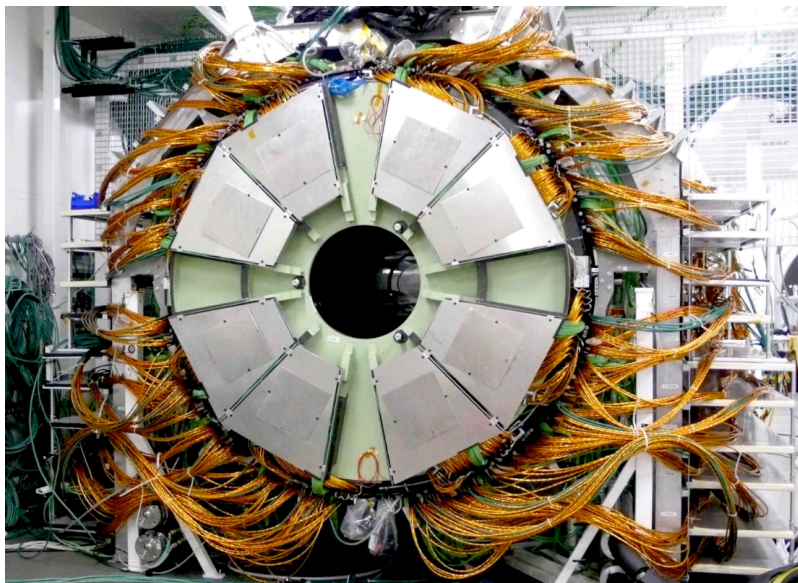
Magnet

Forward Pixel Detector Details

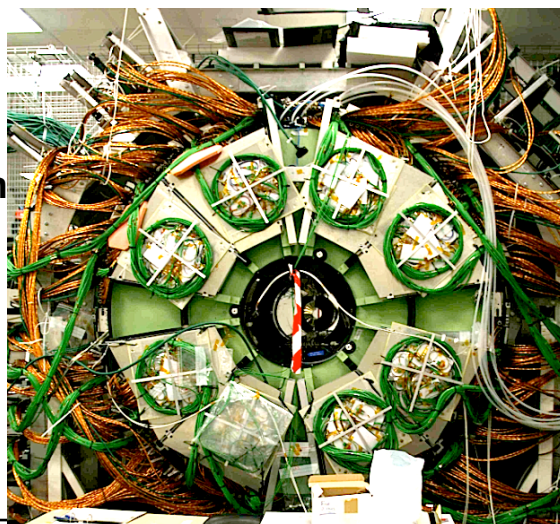


- Collaborating Institutions: Colorado, Cornell, UC Davis, FNAL, U of Iowa, Johns Hopkins, Kansas State, U of Mississippi, U of Nebraska, Northwestern, U Puerto Rico, Purdue, Purdue/Calumet, Rutgers, SUNY/Buffalo, Tennessee, U Virginia, Vanderbilt
- ➡ - Fermilab: 6 physicist, 2 RAs (one based at CERN), 2 Engineers
- Status
 - First THREE (of four) half-cylinders are now at CERN
 - Projected completion of 4th half-cylinder is now late October/early November
 - Spare panels should be done about the same time
 - Prototype installation and transportation fixtures were tested in July by inserting the FPIX into the Tracker just at the end of the Tracker tests at TIF (since removed). Only very small changes required
 - Test in 4 Tesla Magnetic field at FNAL successful
 - Test of FPIX Pilot Run detector inside Tracker showed no significant increase in noise or change of signal of either FPIX or Tracker Inner Barrel
 - ➡ - PLAN TO PUT FPIX PILOT RUN DETECTOR IN MTCC WITH BARREL PIXEL PILOT RUN DETECTOR
 - PLAN TO PUT FULL PIXEL DETECTOR IN FOR 2008 RUN
 - Full MOCKUP of patch panel (PP1) showed it will work
- Issues
 - Commissioning of full detector at CERN
 - Cooling pipes design is behind but now ~75% done
 - Operation – no previous experience from similar detectors – must manage rad damage, worry about machine bkgds
 - Databases are critical to operations
 - Maintenance – detector can (must) be removed between runs and stored and maintained cold at Point 5 (French nuclear regulations)
 - Upgrades - intermediate upgrade necessary due to anticipated radiation damage, starting R&D SOON
- We are confident that we will be ready to install the full pixel detector for the start of CMS and operate it safely so that the entire tracking system is available for early physics.

SiTracker Work Complete at TIF – Move is Beginning



Fibres dressed on
TEC bulkhead in
preparation for
move



**Boxes of Fiber Trunk
Cables removed from TIF**

Silicon Tracker Status Details



- **Collaborating Institutions:** Brown; University of California, Riverside and Santa Barbara; University of Illinois, Chicago; FNAL; University of Kansas; University of Rochester
 - ➔ – **Fermilab: 6 Physicists (2 based at CERN), 1 RA, 1 Eng. (based at CERN)**
- **Status**
 - Completed US fabrication in FY06, Completed TOB integration at CERN in early FY07
 - The Integration of the Silicon Strip Tracker was completed on 21 March 2007
 - The Commissioning of ~ 20% of the Tracker (2M channels) was completed on 18 July 2007.
 - Cosmic Triggers have been taken at 15,10,-1,-10,-15, & 15 OC
 - ~ 5 M triggers have been reconstructed & analysis continues
 - Quality is excellent — few per-mille dead or noisy channels, efficiency > 99%
 - The FPix Commissioning Detector was inserted into the Pixel support tube inside the Tracker at - end.
 - The Fpix Commissioning Detector has been readout with TIB- and No cross talk observed
 - The Move of the Tracker from the TIF to P5 has Started
 - Power and VME Systems have been moved to P5
 - Prepare to Move the Tracker to P5 on ~ 26 September
 - ~ 90% of Power Crates and Backboards installed at P5
 - ~ 90% of all VME Electronics have been installed at P5
 - Have a strong US group resident CERN
 - Currently 12 in long-term residence working on installation and commissioning
 - US DQM and SW group (15-20) is playing a major role, many working from ROC at FNAL
- **Issues**
 - ➔ – Integration, Installation and commissioning is an awesome challenge
 - Installation of the central detectors and services (YB0), including Tracker, is critical path for CMS. Much progress with Peter Sharp in charge
 - installation and commissioning of infrastructure and systems at Point 5 has momentum
 - Operations of the full 11 Million channel microstrip tracker will be a challenge – scale is beyond any microstrip system that has been implemented

DAQ Activities



USC during the Global Run at the End of May (GREM). The HF+ and the Global Trigger were successfully read out together through the full DAQ software chain using the “minidaq” system. The minidaq, global monitoring, event building and most of the subdetector software support were provided by the US CMS DAQ Team.

View from above of the RU-BU machines and switch fabric installation at SX5



UCSD students admire their installation work. A rack of RU-BU machines, powered up and racks of Myrinet switches



- Collaborating Institutions: FNAL, MIT, UCLA, UCSD

➡ – Fermilab: 1 Physicist (based at CERN), 1 CP (based at CERN)

- Status:

- Milestone: Global readout August 2007. These global runs include as many subdetectors as available, although only a small DAQ system, the “minidaq” system installed in USC is used. This system is a small subset of the full DAQ system, where the final hardware cabling and software can be tested, but only with a small subset of DAQ hardware and detector FEDs participating. These global runs also test the timing of the trigger.
 - The minidaq, global monitoring, event building and most of the subdetector software support were provided by the US CMS DAQ Team.
- full RU-BU event builder computer farm is being installed, commissioned in SX5.
 - This RU-BU fabric is planned to replace the minidaq for the September global run, which will then be the first test of a full size event builder. The installation and commissioning of these machines is a USCMS DAQ team project.

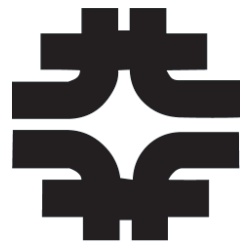
- Issues:

- A lot of software has yet to be written
 - Especially software for Run Control as well as monitoring system, diagnosing and automatically correcting or mitigating problems

➡

- Project relies heavily on physicist labor. Now all effort identified, associated with names
- Concern that as high rate tests continue, problems will appear

US Teams at CERN and in the US



- **Example of US Tracker Group**

- **more than 15 physicists, engineers and technicians at CERN**
 - J.Spalding (FNAL) involved in Tracker Integration; S.Tkaczyk (FNAL) coordinator for Electronic Systems and Online Software; and S.Moccia (FNAL) lead engineer for Point 5 installation preparation.
 - S.Nahn (MIT) Operations co-Coordinator for TIF with M.Eppard(CERN).
 - Brown, UCSB, Riverside (UCR), and MIT scientists spent the last year testing the TOB during assembly and in the current slice test. These activities are supported by US-based physicists and engineers from UCSB, FNAL and Wisconsin.
- **Inside the US many physicists are involved in monitoring and offline tasks**
 - L.Spiegel (FNAL) and L.Shabalina U. of Illinois Chicago (UIC) lead monitoring group, working out of Remote Operations Center (ROC)
 - Y.Gotra (Rochester) co-leading data validation group with P.Azzi (Padova).
 - Scientists from Kansas and UCSB are working on the slow controls and error diagnostics for the tracker.
 - K.Burkett (FNAL) and S.Wagner (Colorado) convene the LPC offline tracking group + O.Gutsche, C.Nöding RAs
 - Scientists from FNAL, UCSB, and UCR are analyzing Cosmics in TOB/TIB



Commissioning

- In addition to the commissioning of sub-components, CMS has started a global commissioning program early this year
 - At Fermilab we are working in the areas of preparations for Data Quality Monitoring
 - DQM through the data path, Trigger monitoring, Trigger DQM etc
 - Bringing up the Remote Operations Centers
 - Participation of Fermilab scientists in global runs
 - Fermilab physicists traveling to CERN and/or participating from Remote Operations Center
 - Fermilab contribution: 3 Physicists, 3 CPs



- **Big Common challenges for all subsystems**
- **new common organization with T. Camporesi and D.Acosta**
 - hardware and online commissioning: central DAQ, global trigger, slice tests with some detectors — few days of global running every 4 weeks
 - thinking through run organization and needs -- collaboration participation
 - overseeing and getting effort from Detector Performance Groups
 - Alignment / calibration group, monitoring and DQM, global views
 - Luminosity, delivery of lumi information
 - preparations for LHC engineering run data taking
- **Commissioning effort has been ramping up steadily**
 - from single detector commissioning focus on global activities in USC and single detector slice tests (e.g. HF full chain readout)
 - DPG become operational — global rendez-vous through global runs
 - hardware — offline — computing
 - engineering run is their main target: use it to verify that we have all it takes to exploit successfully the physics run of 2008
- **Fermilab to contribute strongly to CMS commissioning**
 - including personnel at CERN and work at the Fermilab ROC

1) Detector Installation, Commissioning & Operation

Tracker Inserted

Test Magnet at low current

Last Heavy Element Lowered

Tracker cabled

CMS Cosmic Run CCR_0T
(defined periods Dec-Mar)

Beam-pipe Closed and Baked-out
1 EE endcap Installed, Pixels installed

Cosmic Run CCR_4T

Master Contingency

2nd ECAL Endcap Ready for Installation end Jun'08

2) Preparation of Software, Computing & Physics Analysis

S/w Release 1_6 (CSA07)

CSA07

S/w Release 1_7 (CCR_0T, HLT Validation)

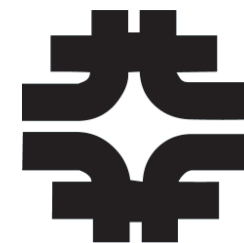
2007 Physics Analyses Completed

S/w Release 1_8 (Lessons of '07)

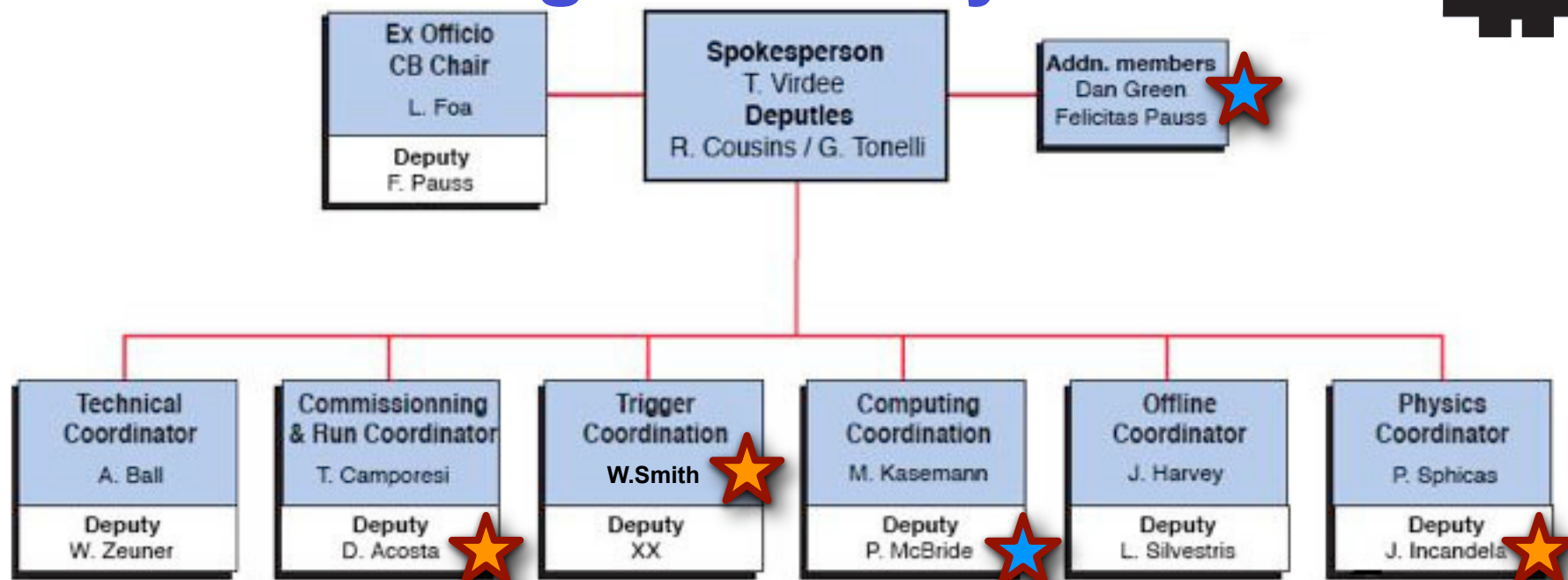
S/w Release 2_0
(CCR_4T, Production of startup MC samples)

MC Production for Startup

All LHC Expt Data Challenge CSA08



Organizing CMS for Data Taking and Analysis



- **Physics, Offline, Computing, Trigger, Commissioning/RunCoord**
 - Detector Performance Groups (reporting to Commissioning/Spokesman)
 - Physics Object Groups
 - Physics Analysis Groups
 - Offline project
 - Computing project
 - Cross activities for integration



- **Strong foundation in detector, software, computing expertise**
 - SiTracker, HCAL, Muons, Pixels, DAQ, Trigger, S&C systems
- **Local expertise in many aspects of physics analyses**
 - Detector Performance
 - ➔ Physics Objects
 - ➔ Physics Signatures
 - This approach benefits from large experience from RunII
- **participate in physics preparations working with our university colleagues**
 - LHC Physics Center and Remote Operations Center
 - Support US community in all aspects related to detector commissioning and performance and physics analyses
 - Provide expertise and leadership in CMS

• Physics Software

- Reconstruction software (Muons, Tracking, HCAL, Simulation)

- Fermilab contribution: 6 Physicists, 3 RAs, 1 CP

- Core Software, including Framework, Storage Manager, etc

- Fermilab contribution: 2 Physicists, 5 CPs

- Distributed Applications

- 3 Physicists, 6 CPs

• Physics Infrastructure

- Computing Facilities, including Tier-1, Analysis Facilities, Grid Interfaces

- 12 CPs

- Offline Infrastructure, including S&C project, physics support, Data operations etc

- 5 Physicists, 2 RAs, 4 CPs



- major deliverable of Fermilab group, working with US and IT collaborators
- new software CMSSW is functional and used throughout the collaboration
 - 15th major CMSSW software release supporting the whole analysis chain
 - incl. calibration/alignment, HLT, pile-up simulation, etc... being verified for physics
- Software project successfully evolved into offline organization
 - Defined procedures for release integration, building & distribution.
 - Control centrally all interfaces and data formats
- Each release of CMSSW is dedicated to supporting the major goals of CMS
 - Feb - CMSSW validation complete
 - May - First Global Readout Test
 - June - HLT Exercise Complete
 - September - Computing Software and Analysis Challenge, CSA07
 - October - Physics Papers prepared
- Data Management, MC Systems operational
 - preparing for 50% system test CSA07
 - regularly produce 50M events/month, large samples for physics, CSA07
 - run Tier-0 reconstruction, Tier-1 re-processing, Tier-2 MC, Grid based analysis

Fermilab Tier-1 and Analysis Facilities

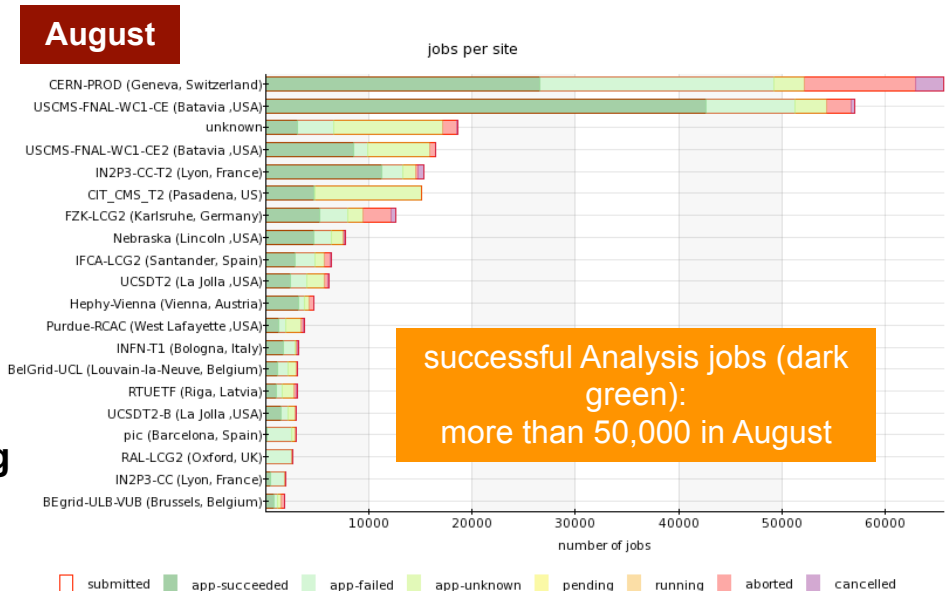
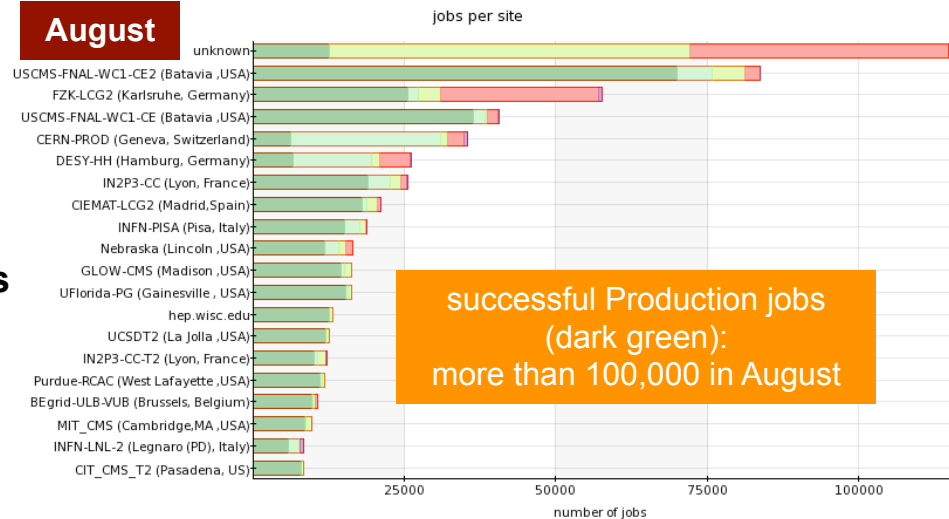


- **Fermilab Tier-1 center hosts major computing facilities**
 - Tier-1 center to support CMS production activities, data hosting, skimming, re-processing, etc
 - LPC-CAF Central Analysis Facility for physics running of LPC users, providing “Tier-2” function
- **finishing CMS “2008 facility”: Tier-1 + LPC-CAF**
 - facility plan for 2008: 7.3 MSI2k, 2.5PB disk, 4.7PB tape
 - facility is now at roughly 5.5 MSI2k, roughly 5000 batch slots, 1.7PB of disk, after installing the FY07 procurements
 - Tier-1 has access to a 20G/s WAN link and 30GB/s of campus networking
- **with slow LHC startup, push last phase procurements to ‘08**
 - facility still ready for initial run start up and physics data taking in 2008
 - LPC-CAF (previously known as UAF) is being ramped up this year
 - delays of procurement help w/ cost due to slow technology developments

Fermilab T1 facility usage → Gutsche's talk



- Fermilab's contributes significantly to the overall CMS computing
 - Major contribution to MC production (own production and archive of samples produced on US T2)
 - Major contribution to standard operations (re-reconstruction and skimming, etc.)
- User analysis contribution goes beyond T1 facility
 - Large user analysis activity not only on the T1 facility
 - LPC-CAF used extensively by Fermilab, US and international collaborators for various analysis purposes
- Operation and extension of facility manpower extensive
 - Admin staff continuously maintains the systems
 - Scaling issues frequently arise while increasing size
 - 4 year ramp-up plan helps solving scaling problems in a timely manner
 - Strong support in the future required for successful operation



Computing, Software, Analysis Systems

- **End of last year: CSA06 tested systems at 25%**
 - End-to-end test, successfully including main work and data flows
 - 207M events/6 weeks processed in Tier-0
 - Calibration, Re-Processing, database access from the Grid
 - data export to Tier-1, analysis skim data to Tier-2
 - >50K/day production and analysis jobs on the Grid
 - Alignment/Calibration/Physics analyses widely demonstrated
- **Software Releases, Computing Systems Commissioning**
 - March — validation of re-engineered software completed -- Done
 - June — HLT exercise complete -- Done
 - Since Apr 2007: monthly global data taking with individual detectors
 - also running cosmics with SiTracker, re-processing of MTCC data
- **started Computing, Software and Analysis Challenge CSA07**
 - computing, software and analysis systems at 50% of 2008
 - emphasis on Tier-0 workflows, analysis at Tier-2 centers
 - run by data operations teams
- **Next Step: getting ready for data taking**
 - October — First physics “papers” prepared



- **Tier-2 sites at U.S. Universities, distributed nature presents both opportunities and challenges**
 - Tier-2 sites are coordinated as part of US CMS RP
 - work well and reliably — joint facilities meetings with Tier-1
 - Data hosted at Fermilab and other Tier-1s, data analysis at Tier-2s
- **Tier-2s provide 40% of all CMS computing resources**
 - bulk of computing that “average” physicists will use is at Tier-2s
 - Tier-2s provide main resource for event simulation
 - Jobs submitted remotely through grid, output archived to Tier-1
 - CSA07 important milestone for Tier-2 computing
- **Fermilab engaged in Open Science Grid**
 - providing infrastructure support, cyber security, expertise
 - Fermilab instrumental for the success of the Tier-2s

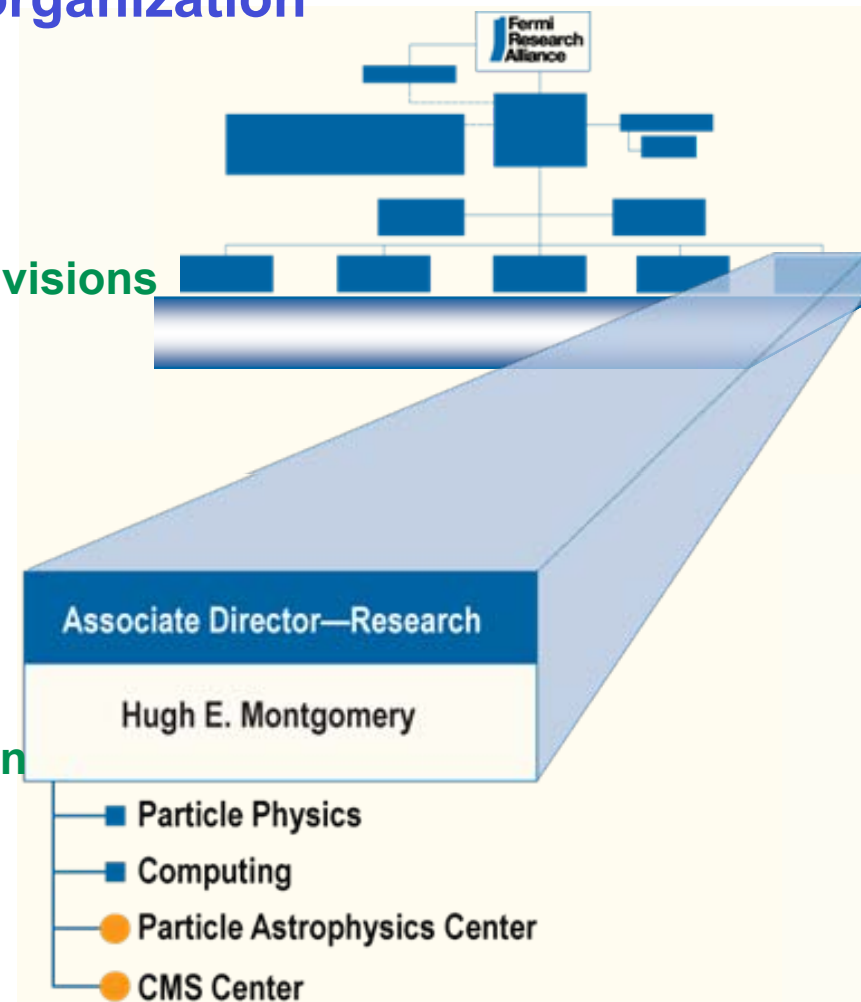


CMS Center Organization at Fermilab



- **CMS Center is part of the new lab organization**

- Created the CMS Center in Dec 2006 to gather all the resources associated with CMS under one umbrella
 - to coordinate CMS efforts across divisions
 - reports directly to the Associate Director for Research
- Enhances U.S. ability to exploit the LHC and attracts physicists to FNAL during the LHC era
 - part of strategy to develop policies and tools that facilitate collaboration between FNAL and research performed elsewhere
- LHC Physics Center LPC
- Remote Operations Center ROC
- CMS Tier-1 Computing and Analysis Facilities (LPC-CAF)
- Research Program Management and Program Office



CMS Center Organization



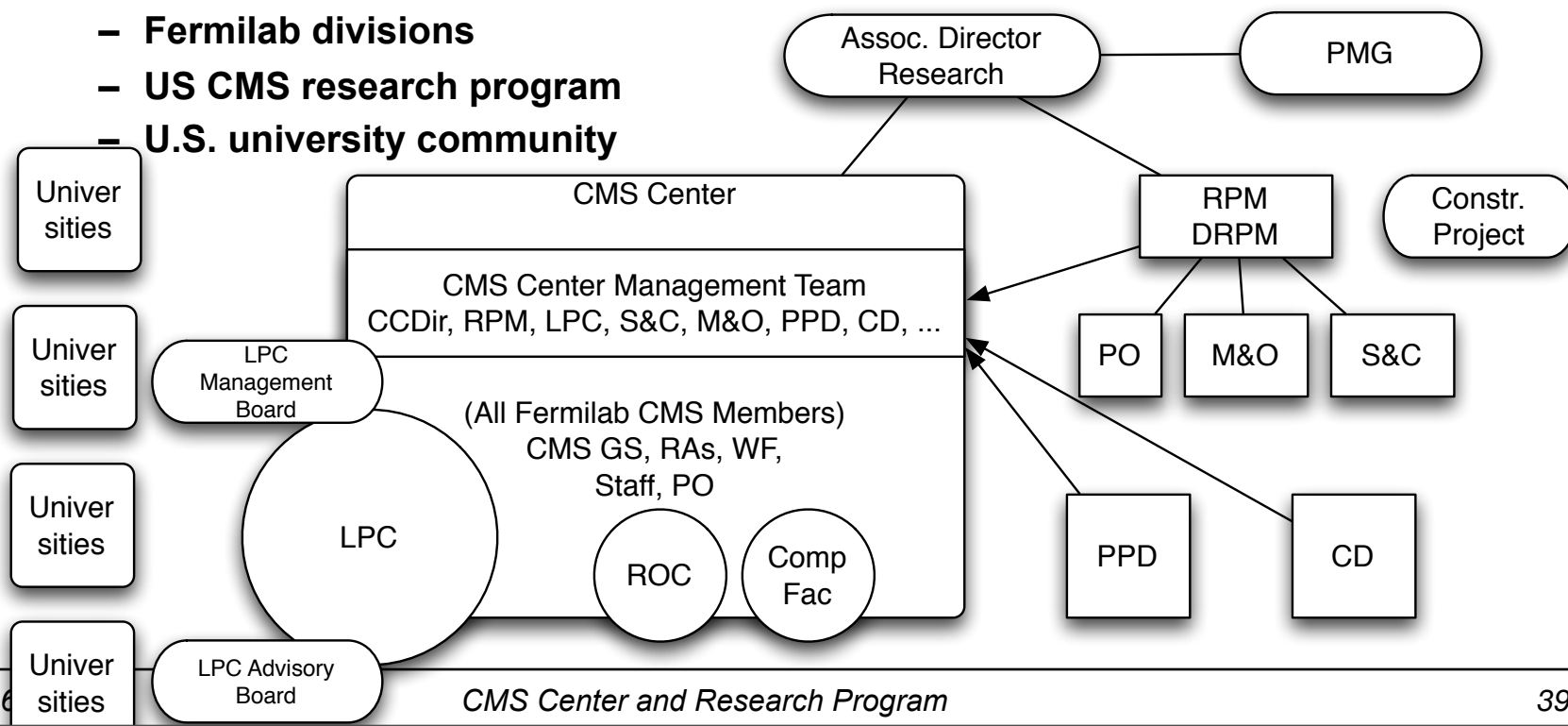
– CMS Center Mission

- To provide overall coordination and management of the Fermilab contributions to CMS and the resources invested in CMS
- To ensure that the Fermilab and U.S. CMS enables U.S. physicists to fully and actively participate in the science made available at the LHC.

– CMS Center is home for all CMS people and efforts at Fermilab

- a multi-dimensionally matrix-ed organization!

- Fermilab divisions
- US CMS research program
- U.S. university community



CMS Center Organization Chart



- some 50 CMS physicists at Fermilab
- CMS Center line org for WF, RA, GS
 - currently 1 Wilson Fellow, 8 RAs, 4 GS
 - all other CMS members stay in Divisions, and are listed in CMS Center org chart
- CMS Center Management
 - CMS Center Director
 - PPD Liaison
 - CD Liaison
 - US CMS Research Program Manager
 - US CMS S&C Manager
 - US CMS M&O Manager
 - LPC Coordinators
 - meeting on a weekly basis

CMS Center Organizational Chart (08/2007)

| | | |
|--|--|--|
| CMS Center Management BAUERDICK, Lothar A.T. – CMS Center Director BUTLER, Joel – U.S. CMS Research Program FISK Ian – U.S. CMS Software and Computing FREEMAN Jim – U.S. CMS Maintenance and Operations GREEN Danel – PPD, LHC Physics Center MCBRIDE Patricia – CD TULLY Chris – LHC Physics Center | | Physics Infrastructure Computing Facilities Tier-1, LPC-CAF, Grids ALBERTS Marina (CP) – CD BAKKEN Jon Alan (CP) – CD FAGAN David (CP) – CD GAINES Irwin – CD HESSELROTH Ted (CP) – CD HOLZMAN Burt (CP) – CD KAISER Joseph (CP) – CD PETRAVICK Donald (CP) – CD PORDES Ruth (CP) – CD SFILIGOI Igor (CP) – CD STIEHR Gary (CP) – CD WU Yujun (CP) – CD Offline Infrastructure BAUERDICK Lothar A.T. – CC FISK Ian – CD GUTSCHE Oliver – CC KLIMA Boaz – PPD MASON David – CC MCBRIDE Patricia – CD ABDULLIN Salavat (CP) – PPD GARTUNG Patrick (CP) – CD MARRAFFINO John – CD RATNIKOVA Natalia (CP) – CD (SEXTON-KENNEDY)(CP) – CD |
| Detectors DAQ O'DELL Vivian – PPD SUZUKI Ichiro (CP) – PPD HCAL ALBROW Michael – PPD ELIAS John E – PPD FREEMAN Jim – CD GREEN Dan – PPD HANLON Jim – PPD KOUSOURIS, K. RA – CC VIDAL Richard – PPD WHITMORE Juliana – PPD WU Wei Min – PPD Piperov Stefan (GS) – CC Muons APOLLINARI Giorgio – TD GEURTS Frank J.M. – PPD BORCHERDING Fred – PPD EARTLY David – PPD YARBA Viktor – PPD Pixels ATAC Muzaffer – PPD BALDIN Boris (E) – PPD BHAT Pushpalatha – PPD (BUTLER Joel Nathan) – PPD HAHN Alan – PPD JOSHI Umesh – PPD KWAN Simon – PPD LOS Serguei (E) – PPD NEWMAN-HOLMES C – PPD TAN Ping RA – CC UPLEGGER Lorenzo RA – CC SiTracker DEMARTEAU Marcel – PPD JENSEN Hans – PPD NOEDING Carsten RA – CC SPALDING William J – PPD SPIEGEL Leonard – PPD TKACZYK Slawek – PPD MOCCIA Stefano (E) – PPD | Physics Software Muon reco BLOCH Ingo RA – CC JAMES Eric WF – PPD Tracking reco BURKETT Kevin WF – PPD GUTSCHE Oliver RA – CC YUMICEVA Francisco RA – CC HCAL reco (ELVIRA Victor Daniel) – CD HARRIS Robert – CD Simulations Banerjee, Sunanda – CD ELVIRA Victor Daniel – CD YARBA Julia (CP) – CD MRENNNA Stephen – CD DQM and Trigger BERRYHILL Jeffrey WF – CC MAESHIMA Kaori – PPD BADGETT William (CP) – PPD Core Software CHEUNG Harry – PPD DAGENHART Dave (CP) – CD JONES Chris (GS) – CD KOWALKOWSKI James (CP) – CD PATERNO Marc (CP) – CD SEXTON-KENNEDY (CP) – CD TANENBAUM William (CP) – CD Distributed Applications AFAQ M Anzar (CP) – CD BLUMENFELD Barry (GS) – CD DYKSTRA David (CP) – CD EVANS David (CP) – CD GUO Yuyi (CP) – CD LUEKING Lee – CD LUKHANIN Gennadiy (CP) – PPD SEKHRI Vijay (CP) – CD WICKLUND Eric – CD | Centers & Offices LHC Physics Center GREEN Dan – PPD TULLY Chris – PrincetonU Remote Operations Center GOTTSCHALK Erik – PPD MAESHIMA Kaori – PPD STONE Alan Lee (CP) – PPD MOKHOV Nikolai – AD Research Program Office BUTLER Joel Nathan – PPD (FISK Ian) – CD (BAUERDICK Lothar A.T.) – CC (FREEMAN Jim) – CD DOODY Tim (CP) – CD HANLON Jim (CP) – PPD KRAMER Tami (CP) – PPD LUSIN Sergei (E) – PPD NAHN Jen OC – CD Admin Support Carrie Farver – PPD Terry Grozis – PPD Terry Read – PPD |

CMS Center M&S Budget



- **total M&S FY07: ~\$1.4M + CMS budget in PPD/CD, FY08 ~\$2.4M**
 - To strongly participate in CMS commissioning and physics preparation
 - Travel to the experiment for >50 CMS physicists
 - travel to experiment is essential and “cost of doing business” at LHC
 - “be there” for commissioning, strengthening ties
CERN—FNAL, CMS—LPC
 - COLA for long-term stays of physicists at CERN
 - M&S for infrastructure supporting some 50 CMS physicists (in divisions)
 - conferences, computer replacements, software
 - M&S budget request for CMS program
 - M&S for LPC travel of invitees, buy-outs, housing, workshop support
 - M&S for SLHC and other R&D of CMS members
 - Guests and Visitor budget request
 - LPC guest, fellows, exchange program
 - important goals to build up the LPC at faster pace as we get close to LHC running
 - GS and visitors for HCAL, Pixel, SiTracker, Software



US CMS Research Program

- **Fermilab is Host Lab for the U.S. CMS Research Program**
 - Project Office, Project Managers, major deliverables like the Computing facilities, LHC Physics Center, Remote Operations Center etc
- **New RP Leadership in place**
 - Joel Butler/Fermilab RPM, Dan Marlow/Princeton DRPM
 - Institutional Advisory Group and Technical Advisory Board
 - “advisory boards” to coordinate the Research Program efforts
- **Successful reviews for S&C and M&O in Jan/Feb and Aug 2007**
 - JOG: funding agencies happy with US CMS management team
- **CMS Research Program Budget spending at Fermilab**
 - DOE funding for FY07 was \$23.2M, Guidance for FY08 is \$25.4M
 - FTE funded at Fermilab FY07 ~46FTE, FY08 ~48 FTE
 - FY08: 15 FTE in M&O, 33 FTE in S&C, ~\$5.5M Computing Equipment

Support of Personnel to Maintain and Operate the Detector



- **Each US subsystem has been asked to**
 - Prepare a list of resource needs, including personnel, necessary to complete its obligations in installation, integration, commissioning, operations and maintenance
 - Determine its available resources and resolve any discrepancies with needs
 - Do this in the context of its CMS counterpart
- **Key issues will be**
 - COLA and support for personnel
 - **Engineers and technical personnel will be supported by the RP**
 - **A significant part of the support for physicists must come from the CORE program**
 - Maintaining and extending the support for university groups is essential for success



Memoranda Of Agreement (MoA)

- CMS is asking institutions or consortia to prepare MoA's for Maintenance and Operations of the CMS Detector at CERN
 - Will be done by subsystem as well:
 - Tracker
 - Ecal
 - Hcal
 - Muon
 - Trigger
 - DAQ
 - Core Computing
 - Offline Software
 - Run and Technical Coordination
- RP is organizing the US response to the CMS groups to make sure that it respects the boundary conditions of funding in both the Research Program and the Core Program.



- **The SLHC schedule is not yet known.**
 - We assume intermediate Pixel Detector 2011, and that the SLHC upgrade would need to complete the detector in 2014-2015 for installation during shutdown for machine upgrade in 2015-2016.
- **CMS submitted an EOI for the CMS upgrade for SLHC to LHCC**
- **USCMS has written a strawman plan for DOE**
 - requests \$145M funding starting in 2010 (corresponding to US share)
 - Expect heavy US involvement in
new pixel, new tracker, track trigger, trigger upgrades.
 - **USCMS RP starts to provide R&D funds to prepare for the upgrade**
- **A series of “upgrade workshops”**
 - **tracker upgrade workshop at Fermilab, common CMS-Atlas upgrade workshop on electronics at CERN, sensor meeting, tracker readout meeting, CMS upgrade simulation meeting, etc**
- **CMS is forming the CMS upgrade organization**
 - **Fermilab is engaging in the CMS upgrade for the SLHC**



LHC Physics Center LPC

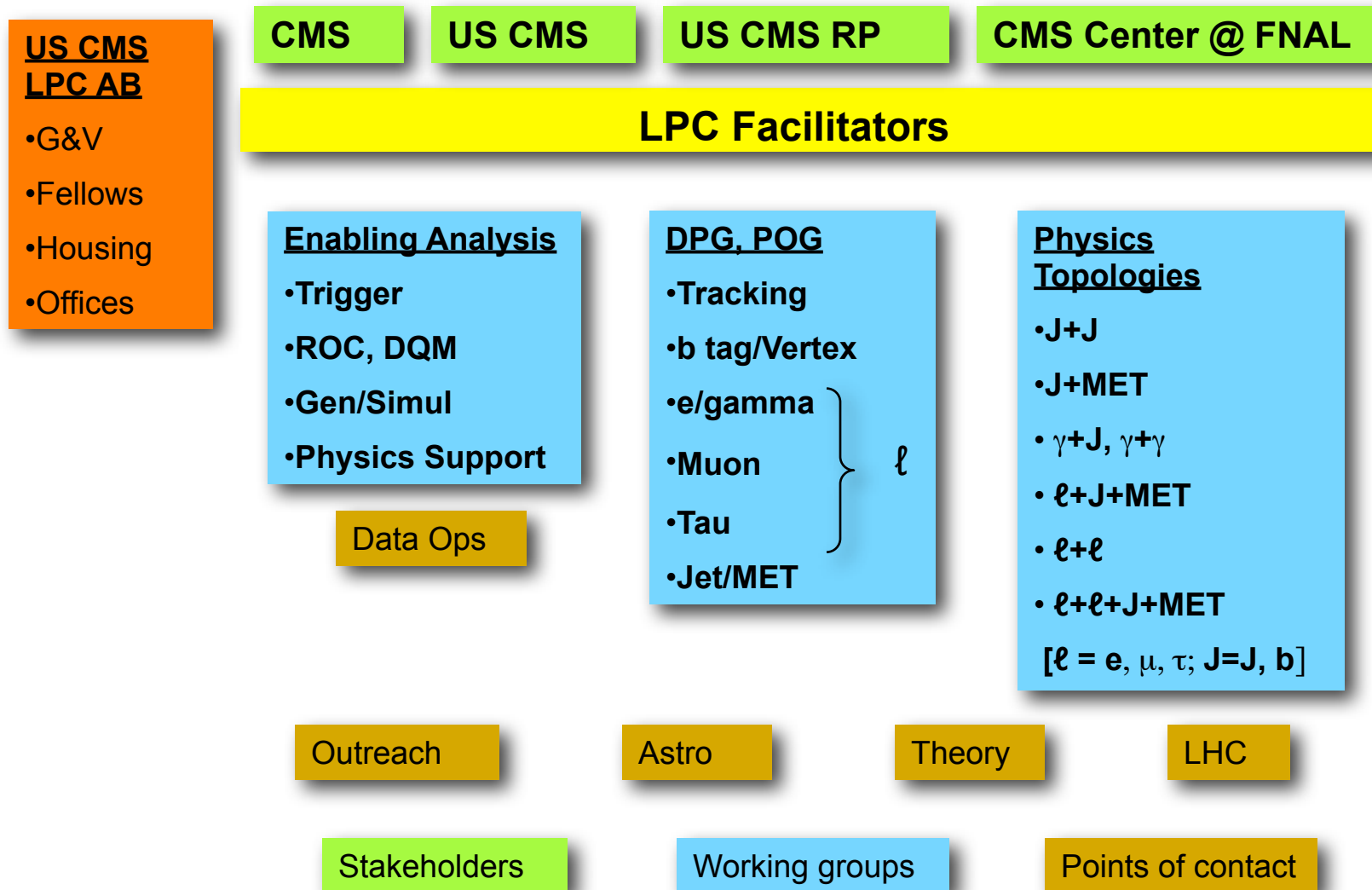
- **The LPC was created for US physicists to make a strong contribution to the CMS experiment**
 - a center with critical mass of scientists working together and resources to analyze CMS data and to commission and monitor experiment
 - a place to visit to get support and help with analysis and software issues
 - local center for shared effort on CMS and the Tevatron
 - help for a graceful transition between Tevatron experiments and CMS
- **Fermilab provides strong support for the LPC**
 - center of activity on 11th and 10th floor of the FNAL high rise
 - meeting rooms, video conferencing, computing facilities
 - access to CMS experts, contacts to Tevatron physicist, theorists
- **The LPC is very active and attractive to U.S. Universities**
 - 28 U.S. CMS Universities have offices at the LPC
 - working groups on physics objects, trigger, simulation, physics meeting
 - organizing workshops, tutorials, weekly US CMS meeting etc



- **Committee to advise Fermilab on LPC structure and leadership**
 - representation from USCMS, CMS, LPC, AB, CB,
- **Principal Recommendations**
 - LPC to be led by two LPC Coordinators with staggered two-year terms.
 - LPC Coordinator Selection Committee, identify short ranked list
 - candidates nominated by the U.S. CMS Collaboration
 - Fermilab Director to appoint the LPC Coordinators from the short list
 - LPC Management Board
 - chaired by the LPC Coordinators, to direct the LPC program of work, to draw up policies and to provide the forum for close coordination with activities in CMS, in U.S. CMS, and in the CMS Center.
 - LPC Advisory Board LPC-AB
 - provide advice to the LPC Coordinators, give regular feedback on LPC performance to the LPC-MB and report to the U.S. CMS Collaboration and Fermilab
- **LPC Coordinator selection was completed in July, 2007**
 - Dan Green/Fermilab and Chris Tully/Princeton U appointed
 - see C.Tully's talk in parallel session



LPC Org Chart → C.Tully's talk



Remote Operations Center ROC



- Remote Operations is now integral part of the CMS plan for running the detector
 - two CMS Remote Operations Centers
 - at CERN the “CMS Centre” on Meyrin site
 - at Fermilab in the “LHC@FNAL” at WH1
 - construction of LHC@FNAL ended early 2007, at CERN only an initial room for Data Operations already exists
 - CMS is rebuilding the old PS control room
- Good examples of how to use the ROC already exist
 - first steps were shift-taking during the Magnet Tests/Cosmic Challenges and the Global Runs
 - other examples are SiTracker data taking and HCAL Testbeam activities
 - The Data Operations task in CMS Computing is planned to be shared between teams based at CERN and at Fermilab, has successfully started for CSA07

Remote Operations at LHC@FNAL



Used by Tracker Slice Testers, LHC Operations Developers, test beam data analyzers, global run shifters, DQM users, Tier-1 operations, CMS Data Operations



- **Important opportunity for CMS, complementing LPC**
 - enable US physicists to be successful contributors to CMS
 - make US physicists effective in providing “service contributions” to CMS
 - **with the goal to do shift work from the ROC!**
 - make Fermilab’s contributions to the LHC visible and promote the LHC
- **A Place**
 - That provides access to information in a manner that is similar to what is available in LHC and CMS control rooms at CERN
 - Where members of the LHC community can participate remotely in LHC and CMS activities
- **A Communications Conduit**
 - Between CERN and members of LHC community located in North America
- **An Outreach tool**
 - Visitors will see current LHC activities
 - Visitors will see how future international projects in particle physics can benefit from active participation in projects at remote locations.

Summary, Conclusions



- **CMS is coming together**
 - in terms of components in the underground cavern, and as a whole experiment collaboration
 - schedule very tight, but CMS is holding to the plan for the moment
- **CMS plan emerges for commissioning and operating detector, and to prepare collaboration for data taking and analysis**
 - Fermilab to contribute as strongly and efficiently as we can
 - presence at CERN and facilities at home are key
 - strong Fermilab involvement in MTCC, CSA07, commissioning
 - steps toward learning how to operate CMS for physics
- **Fermilab organized CMS efforts in CMS Center**
 - strategic decision to ensure a vital role for the US HEP community in the exploitation of the LHC physics program.
 - Major CMS roles for LPC, ROC, detector&software expertise, computing
- **Fermilab strong contributor to get CMS ready for physics**



Backup Slides



LHC Machine Status



Repair of the Triplets

An inner triplet assembly of quadrupole magnets at Point 8-Right of the LHC was successfully tested in the accelerator tunnel on Friday, July 13.

Q1 and Q3 magnets, at either end of the triplet assembly, fitted with a set of four metal cartridges of a compound design consisting of an aluminum alloy tube and an Invar rod to allow them to function over a broad range of temperatures.



All of the triplet quadrupole magnets have been repaired

A Q1 magnet assembly with cartridges held in place by the four earlike brackets bolted to the outer flange



Situation in Sectors

Arc 1-2 and 2-3: interconnection on-going, closure in Sept.

Arc 3-4: closed, leak tests of individual sub-sectors in progress

Arc 4-5: cooled at 80K, ELQA tests on going

Leak appeared in DFBA at 4R, now fixed → 3 weeks delay

New leak appeared in 5L, need to be localised and fixed...

Arc 5-6 and 6-7: closed, leak tests of individual sub-sectors on-going

Arc 7-8: warmed-up after partial power tests (no low- β)

Replacement of MB1055 done, repair in progress according to schedule

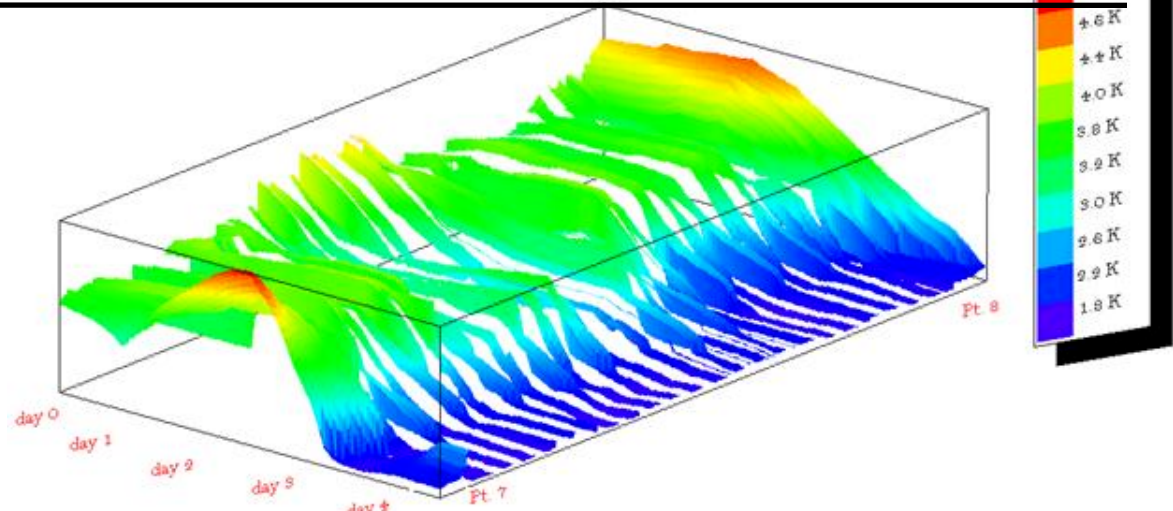
Problems with Plug in Modules (PIM)

Arc 8-1: closed and pressure tested, flushing started

One leak still not fixed, localised in cold mass of Q17.R8

First Cooldown: Sector 7-8

Magnet temperature profile along Sector 7-8 during final cool down to He II



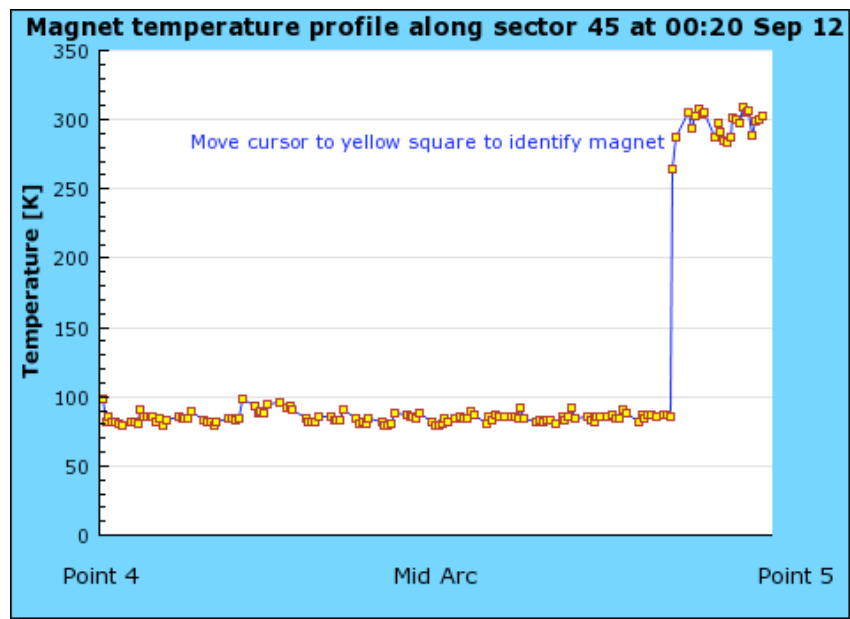
- From RT to 80K pre-cooling with LN2. 1200 tons of LN2 (64 trucks of 20 tons). **Three weeks** for the first sector.
- From 80K to 4.2K. Cool-down with refrigerator. **Three weeks** for the first sector. 4700 tons of material to be cooled.
- From 4.2K to 1.9K. Cold compressors at 15 mbar. **Four days** for the first sector.
- First sector cooled down to nominal temperature and operated with superfluid helium; teething problems with cold compressor operation have now been fixed.

Cooldown of Sectors 4-5, 8-1



Sector 45

Last week **completed electrical qualification of sector 45**. All circuits powered via the DFBs were tested at 50 V. The **leaking sub-sector close to Point 5 has been brought to room temperature**. All the efforts concentrated to localize and then to repair the leak which is of the order of 1 mbar l/s.



Sector 81

After one week of conditioning, **flushing of the sector started on Monday 10th**. The SSS replacing Q17L7 (which has a leak on the cold mass) is being prepared for cold tests in SM18. Installation of this SSS will take place together with the localization and the repair of a leak in the inner triplet assembly left of Point 1.

<http://hcc.web.cern.ch/hcc/>



Sector 7-8

The consolidation campaign is nearing its end: eight vacuum sub-sectors are fully repaired and ready to be closed for the vacuum tests.

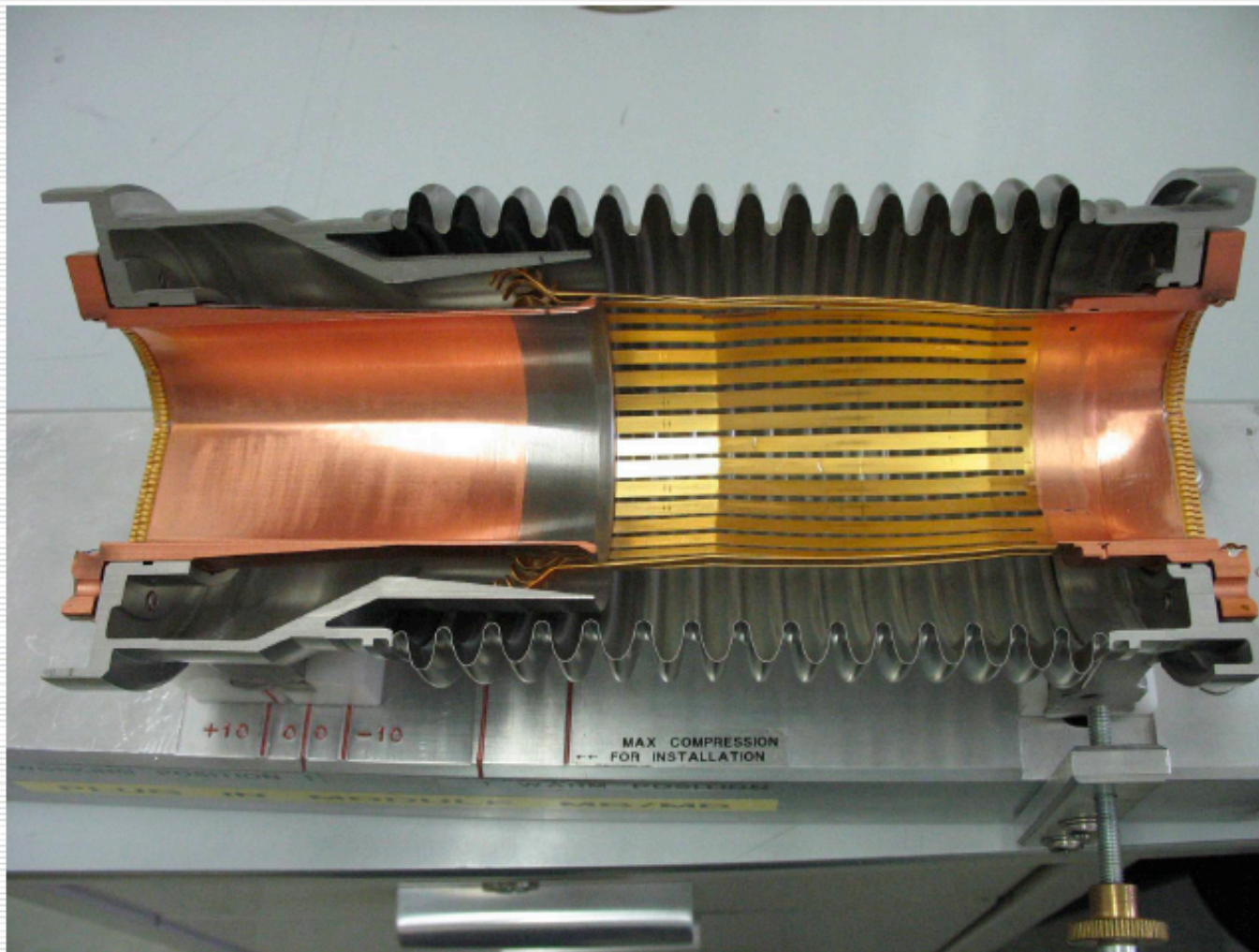
The total number of damaged plug-in modules on the beam lines in the arc is five out of 450: together with the five in the dispersion suppressor region (where damage was expected)

In the inner triplet region left of Point 8, after the repair of Q1 on the surface, the magnet was re-installed and the interconnection of the inner triplet magnets is progressing.

Plug-In Modules



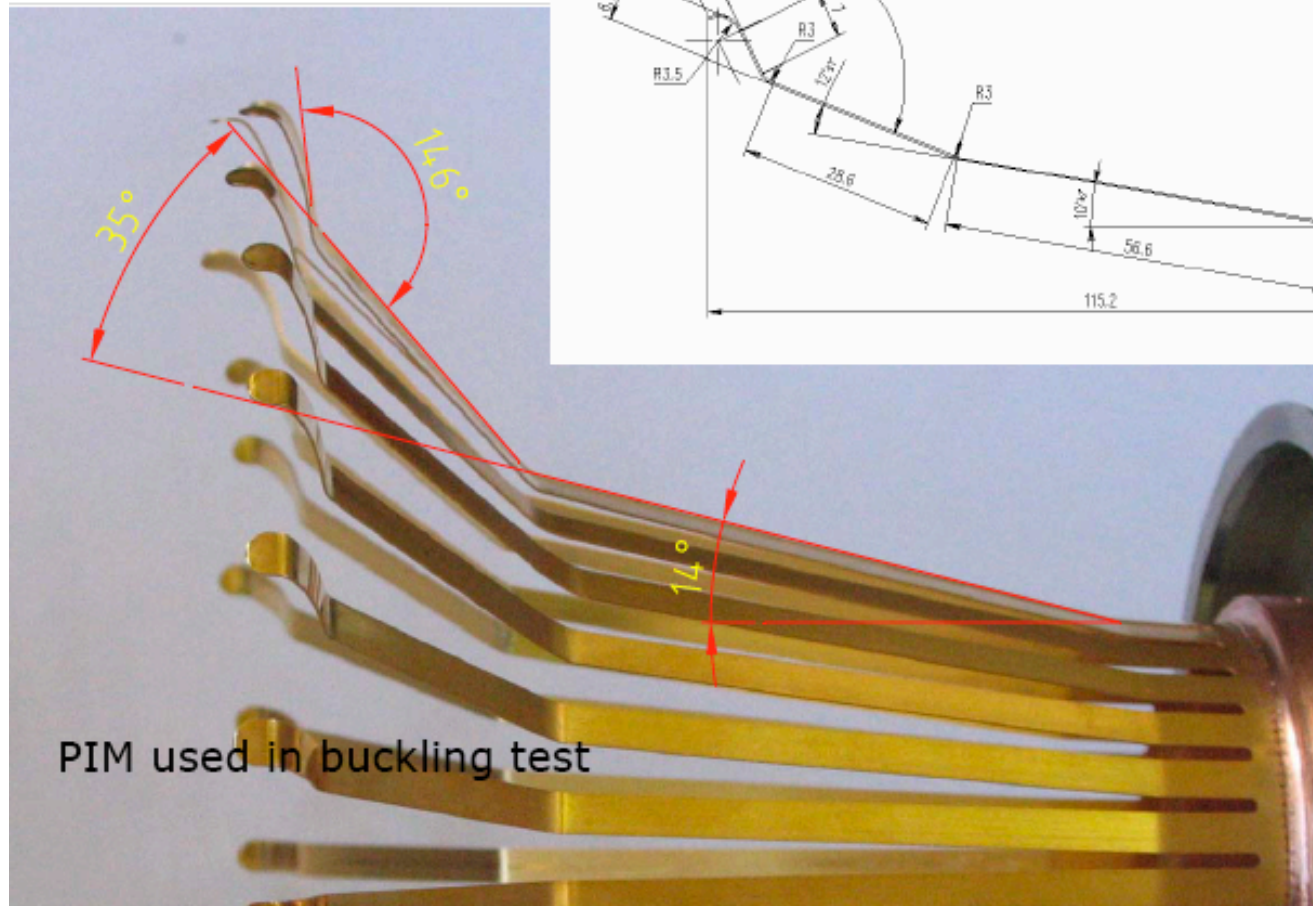
An MM plug-in in equivalent cold position



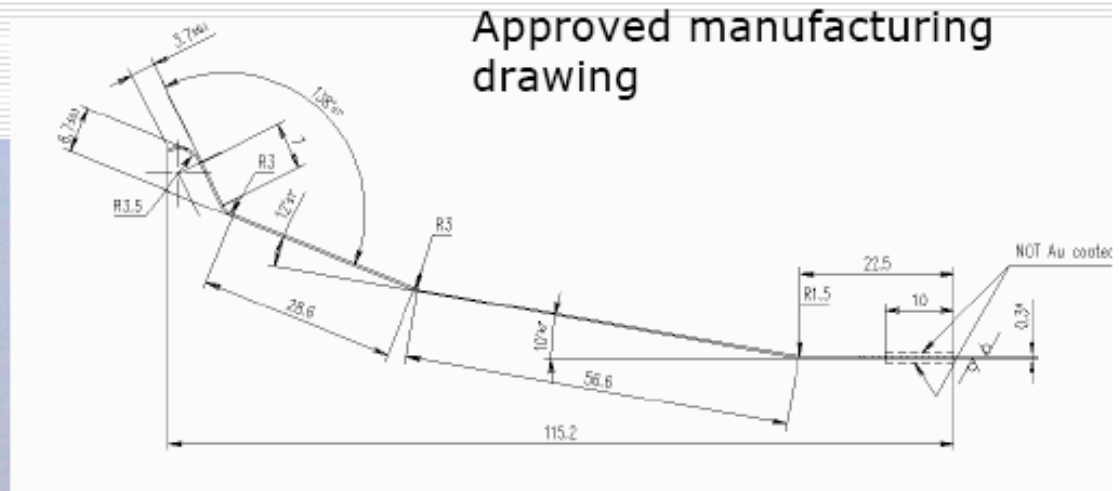
Details: PIM Fingers



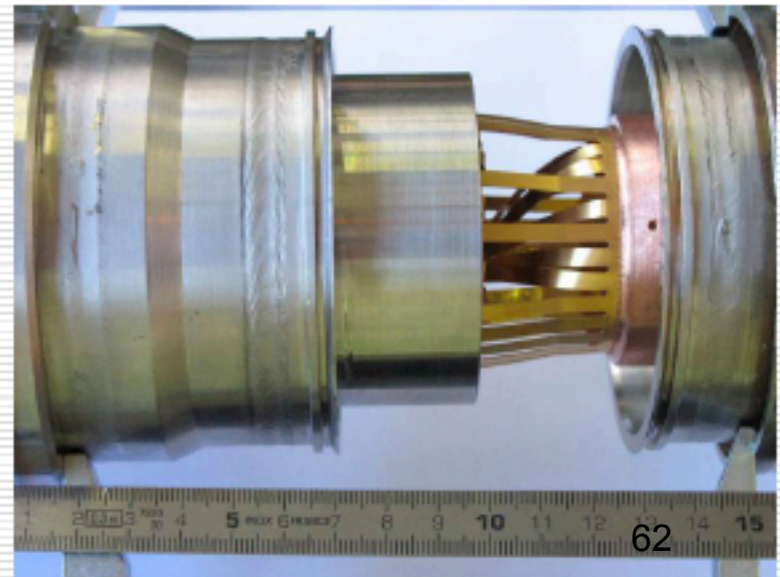
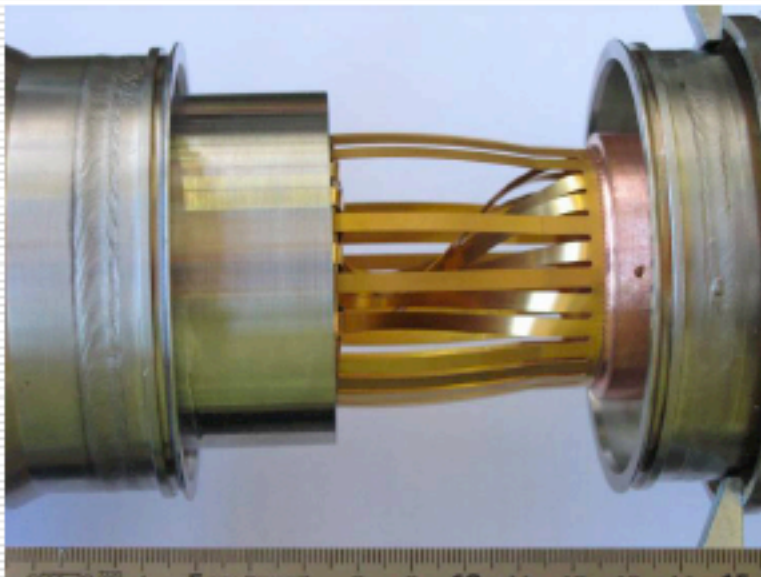
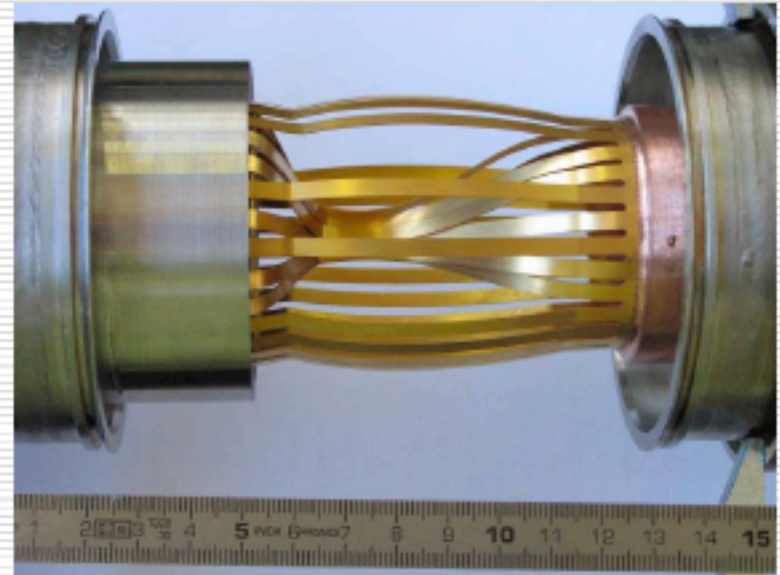
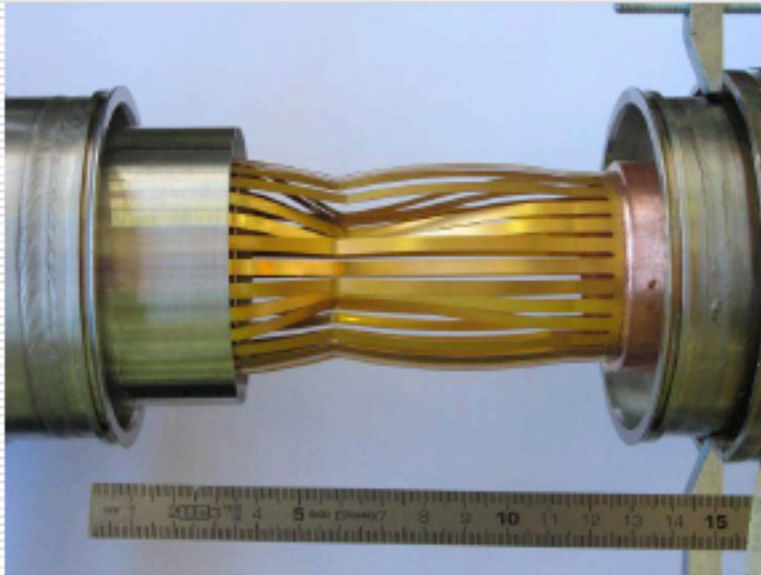
Tested PIM with bending angles out of tolerance



PIM used in buckling test



Damaged Plug-In Modules

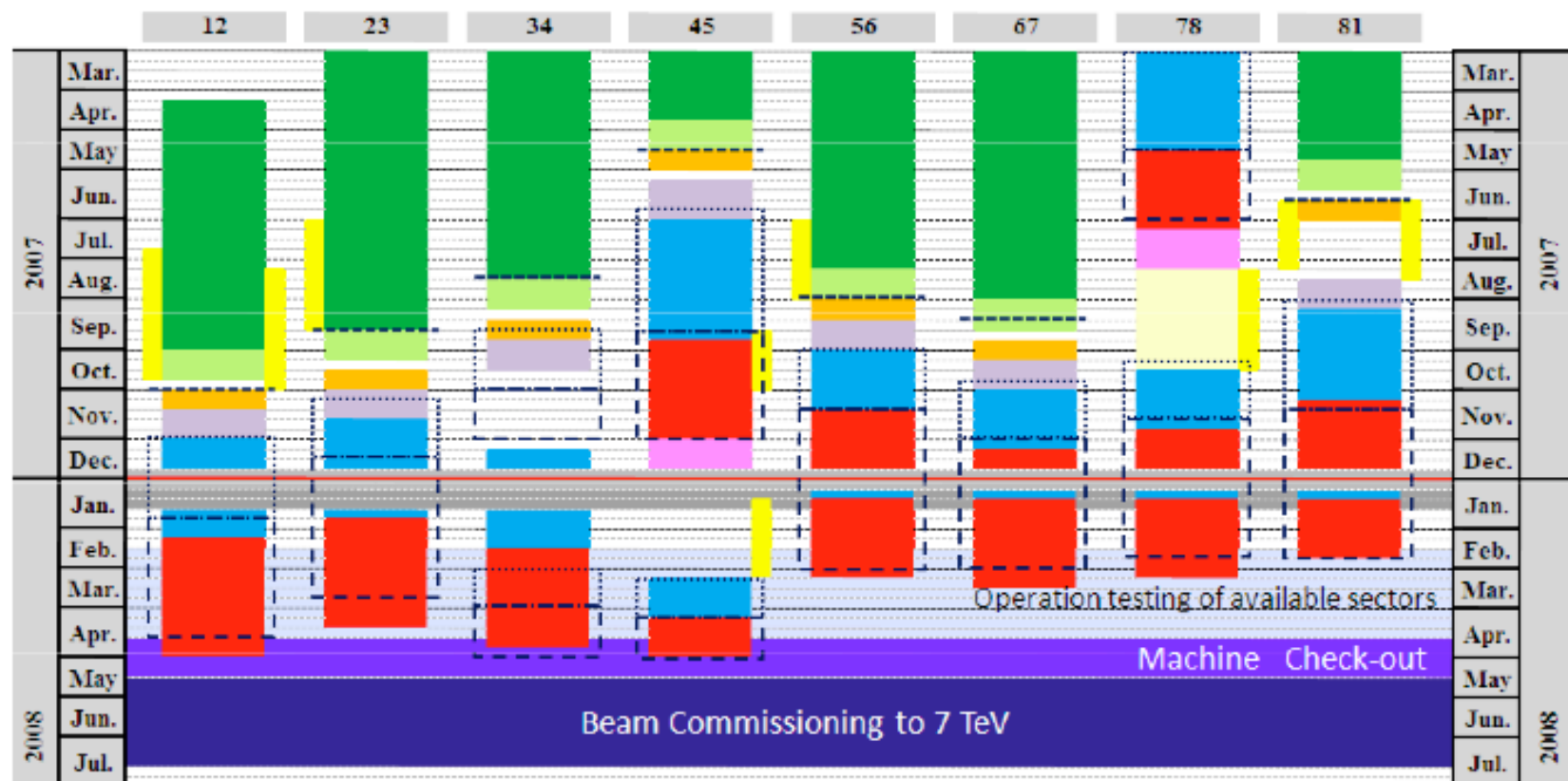


General LHC Schedule (L.Evans)



- Engineering run originally foreseen at end 2007 now precluded by delays in installation and equipment commissioning.
- 450 GeV operation now part of normal setting up procedure for beam commissioning to high-energy
- General schedule has been revised, accounting for inner triplet repairs and their impact on sector commissioning
 - All technical systems commissioned to 7 TeV operation, and machine closed April 2008
 - Beam commissioning starts May 2008
 - First collisions at 14 TeV c.m. July 2008
 - Luminosity evolution will be dominated by our confidence in the machine protection system and by the ability of the detectors to absorb the rates.
- No provision in success-oriented schedule for major mishaps, e.g. additional warm-up/cooldown of sector

General Schedule up to date – 03 August 2007



General schedule Baseline rev. 4.0

**** Global pressure test & Consolidation

□ Cool-down

□ Powering Tests

■ Interconnection of the continuous cryostat

■ Leak tests of the last sub-sectors

■ Inner Triplets repairs & interconnections

■ Global pressure test & Consolidation

■ Flushing

■ Cool-down

■ Warm up

■ Powering Tests

Expectations of Luminosity Buildup



| Parameter | Phase A | Phase B | Phase C | Nominal |
|---|------------------------------|---------------------|------------------------|-----------|
| k / no. bunches | 43-156 | 936 | 2808 | 2808 |
| Bunch spacing (ns) | 2021-566 | 75 | 25 | 25 |
| N (10^{11} protons) | 0.4-0.9 | 0.4-0.9 | 0.5 | 1.15 |
| Crossing angle (μrad) | 0 | 250 | 280 | 280 |
| $\sqrt{(\beta^*/\beta_{\text{nom}}^*)}$ | 2 | $\sqrt{2}$ | 1 | 1 |
| σ^* (μm , IR1&5) | 32 | 22 | 16 | 16 |
| L ($\text{cm}^{-2}\text{s}^{-1}$) | $6 \times 10^{30} - 10^{32}$ | $10^{32} - 10^{33}$ | $(1-2) \times 10^{33}$ | 10^{34} |

J. Wenninger

Phase A: Luminosities



Approx 30 days of beam time to establish first collisions

1 to N to 43 to 156 bunches per beam

Pushing gradually one or all of:

Bunches per beam

Squeeze

Bunch intensity

IP 1 & 5

| Bunches | β^* | I_b | Luminosity | Event rate |
|-----------|-----------|--------------------|----------------------|------------|
| 1 x 1 | 18 | 1010 | 10^{27} | Low |
| 43 x 43 | 18 | 3×10^{10} | 3.8×10^{29} | 0.05 |
| 43 x 43 | 4 | 3×10^{10} | 1.7×10^{30} | 0.21 |
| 43 x 43 | 2 | 4×10^{10} | 6.1×10^{30} | 0.76 |
| 156 x 156 | 4 | 4×10^{10} | 1.1×10^{31} | 0.38 |
| 156 x 156 | 4 | 9×10^{10} | 5.6×10^{31} | 1.9 |
| 156 x 156 | 2 | 9×10^{10} | 1.1×10^{32} | 3.9 |



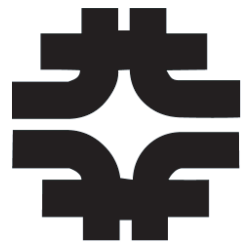
- **LPC Mission is**

- To facilitate the participation of U.S. physicists in CMS data analysis and scientific research
- To provide services that more fully enable all US CMS physicists interested in participating in CMS, in particular by helping US CMS stay synchronized with CMS
- To help to generate and maintain strong positive relationships between US CMS and the CMS collaboration
- To provide help for a graceful transition between the currently operating experiments and CMS for those physicists participating in both.

- **Components of the LPC are**

- A “brick and mortar” location for US CMS physicists to find on all aspects of data analysis, particle ID, software, and event processing within the U.S., working during hours convenient for U.S.-based physicists
- A coordination point that allows U.S. physicists easier access to experts
- A place that encourages, fosters, and helps optimize distributed work and daily collaboration among groups residing at sites throughout the U.S. and groups overseas during feasible working hours
- A place for workshops, conferences/gatherings on LHC physics
- A place to assist in the training of graduate and postgraduate scientists, as well as a center that fosters training for students and postdocs working at their home institutions
- A center for the development of software and physics analysis in the U.S.
- A place that provides opportunities for U.S. physicists who choose to work in this way to organize their contributions to CMS physics: while organizing CMS physics is the purview of the CMS physics organization, the LPC will set up an appropriate and agreed upon structure to assist in this task.
- A “Remote Operations Centers” that CMS physicists can use to participate in data taking and data quality monitoring of the CMS experiment in the U.S.

LPC is Attractive for US Universities



- **June LPC Physics Workshop**
 - some 80 participants
 - followup planned for next week
- **CMS TUTORIALS sessions**
 - June, workshop participants
 - Mar 23, 2007: 21 participants
 - Nov 9, 2006: 26 participants
 - Jul 12, 2006: 40 participants
 - Jun 07, 2006: 37 participants
 - Plus 9 sessions of CMS101 since Sept 04





P. Sphicas,
CMS Physics
Coordinator

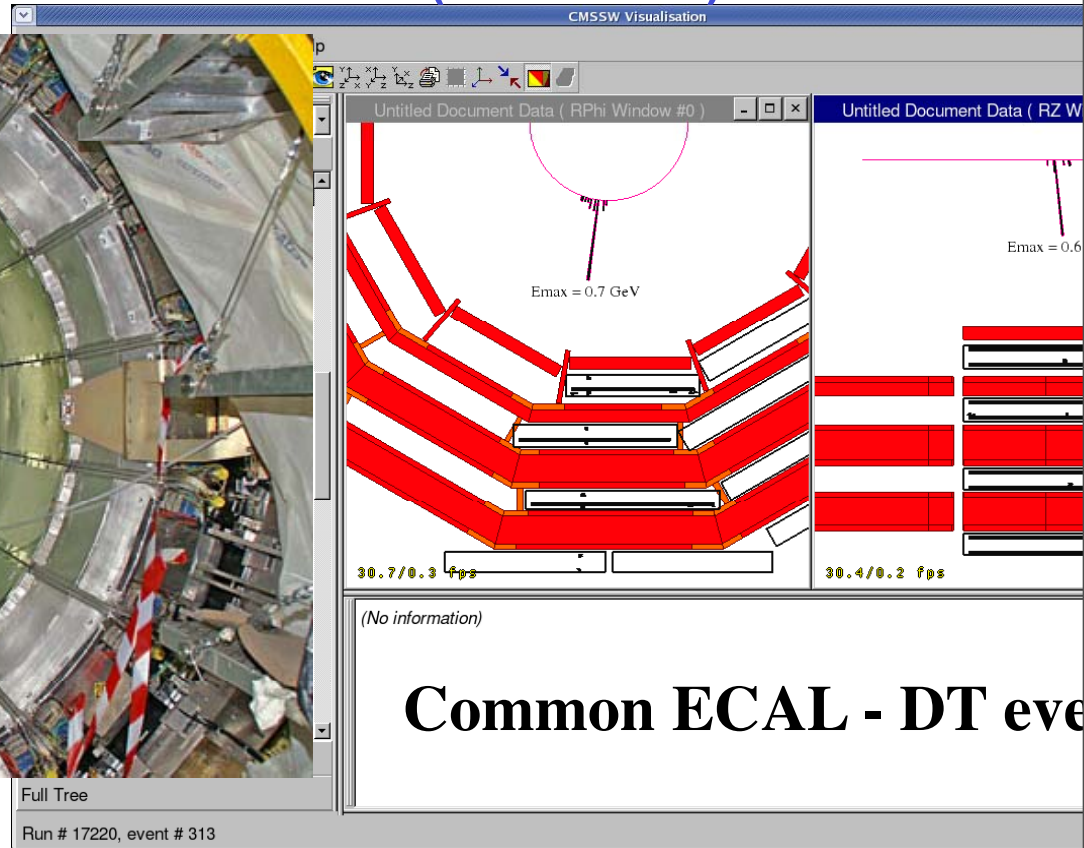
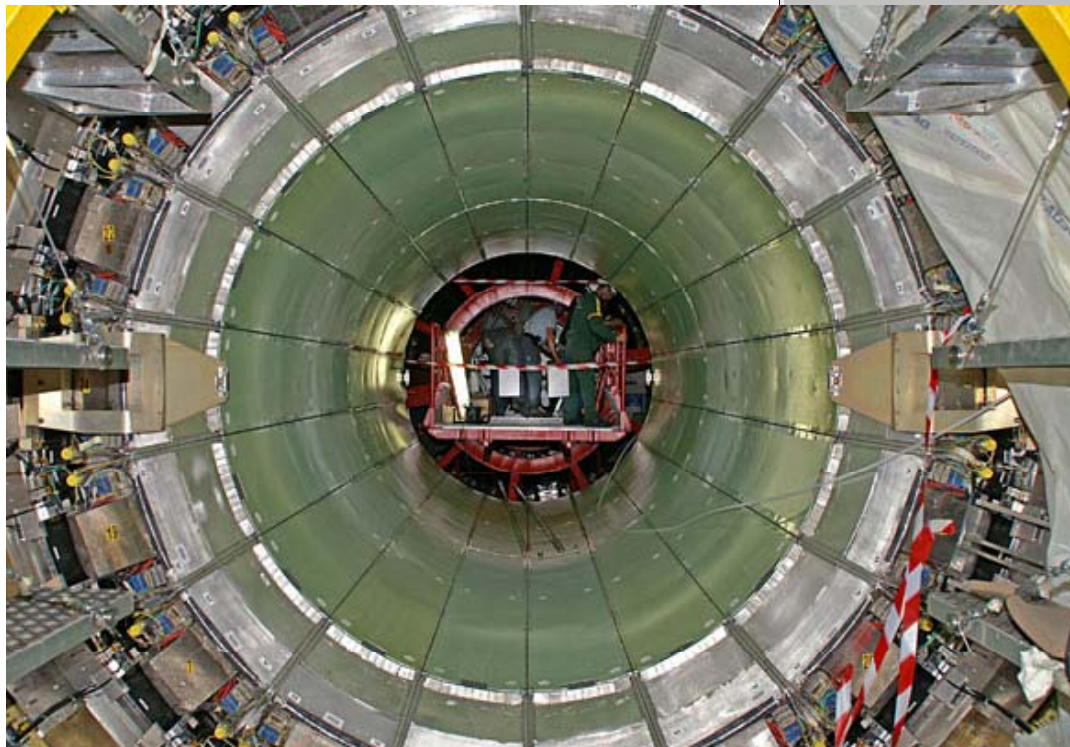
Summary

- From the “physics” side of things, we have high hopes that the LPC will contribute in very significant ways to the program of work of CMS.
 - ◆ And even beyond “physics”, the LPC can take responsibility for major tasks in what can be called the “physics operation” of the experiment. Because it has three major ingredients:
 - the (human) critical mass,
 - the software expertise as well as
 - the computing resources
- Making CMS to work will be a real challenge, and will need all the experience, wisdom and ability in the collaboration.
 - ◆ And the LPC is a big fraction of the total EWA of CMS.

Commissioning: Global Runs



- example of Barrel Ecal — Barrel Muon (Drift Tube) readout

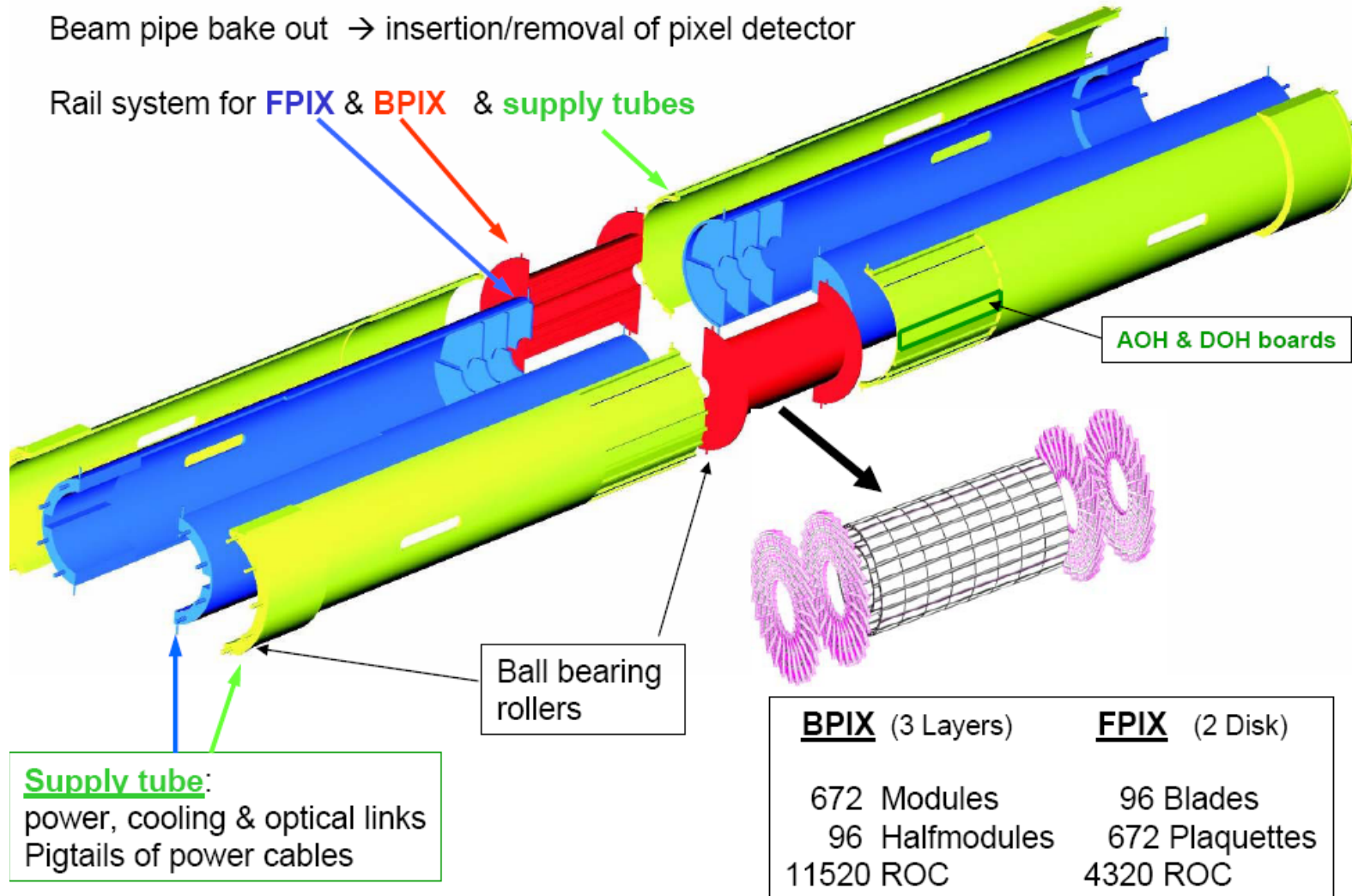




The CMS Pixel System

Beam pipe bake out → insertion/removal of pixel detector

Rail system for **FPIX** & **BPIX** & **supply tubes**



CMSSW Software Release Plan



GEN+SIM production with 14x

DIG+RECO production with 15x

Pre CSA07
50Mevts/mth

CSA07

Cosmic Run

MC Production
for startup
100M evts/mth

June

July

Aug

Sep

Oct

Nov

Dec

Jan

Feb

Mar

1_6_0 : Opened July 2, closed July 23, deployed Sept 3
 Prepare for CSA07 and Global Runs (Sep-Oct)
 Integrate HLT components developed for HLT exercise
 Use HLT trigger paths to create streamed primary
 datasets for testing analysis and calibration data-
 flows & work-flows

1_7_0 : Open Sept 18, Close Oct 2, deploy Oct 26
 Prepare for Cosmics Run
 Allow backward incompatible changes in geometry &
 data formats

1_8_0
 Integrate changes resulting from CSA07 experience
 Continue production of MC samples required for on-
 going detector and physics studies

2_0_0
 Integrate changes resulting from Cosmic Run
 experience
 Start production of physics MC samples 3 months
 before start of data-taking